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ID2 - Course book

Unit ID2: Do – Controlling workplace health issues

Learning outcome 9

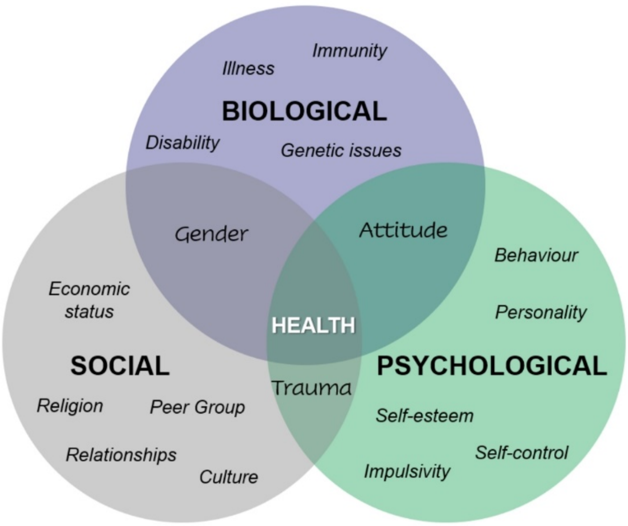
- You will be able to advise the organisation on a range of common workplace health issues and/or hazards including how these can be assessed and controlled.

9.1: Occupational health services and equality in the workplace

The principles and benefits of vocational rehabilitation

The Basic Principles of the Bio-Psychosocial Model

The bio-psychosocial model of health and illness is a framework that states that interactions between biological, psychological, and social factors determine the cause, manifestation, and outcome of wellness and disease. Historically, popular theories like the nature versus nurture debate posited that any one of these factors was sufficient to change the course of development. The bio-psychosocial model argues that any one factor is not sufficient. It is the interplay between people's genetic makeup (biology), mental health and behaviour (psychology), and socio-cultural environment (social world) that determine the course of their health-related outcomes.



The Bio-psychosocial model of health

Health promotion must address all three factors, as a growing body of scientific literature suggests that it is the combination of health status, perceptions of health, and socio-cultural barriers to accessing health care that influence the likelihood of a patient engaging in health-promoting behaviours, like taking medication, proper diet, or nutrition, and engaging in physical activity.

For example, a doctor who ignores the bio-psychosocial model may be as compassionate and ethical as the next, yet compassion and ethics alone will not help a physician to formulate an effective intervention for an asthma sufferer who continues to smoke, or a 50-year-old woman with a family history of breast cancer who "forgets" to perform breast self-examinations and who has cancelled her last three annual check-ups because she was "too busy" at work.

The importance of 'reasonable adjustments' for workers with physical and mental ill-health

There are a several reasons why employers should make reasonable adjustments for people with physical and mental health conditions. From a legal point of view, the Equality Act (2010) outlines an employer's duty to make reasonable adjustments for people with disabilities in order to ensure that they have the same access to everything that involves gaining or keeping employment as a non-disabled person.

From a business point of view, proactive management of employees' mental and physical health can produce a range of benefits for employers. These include reduction of sickness absence, greater staff engagement and productivity, and reduced staff turnover, recruitment, and costs.

Making a few small adjustments to enable a worker to continue doing their job is far less expensive than the costs of recruiting and training a new employee.

According to the (UK) Equality and Human Rights Commission, the average cost is just £75 – with many adjustments costing nothing!

The role and benefits of 'pre-placement' assessment

In some countries, it is legal to make job candidates undergo a health assessment before a job offer is made. In other countries, such as the UK, this is illegal. In such situations, the organisation can only require a pre-placement health assessment after the job offer has been made. This avoids discrimination against the sick and disabled.

The pre-placement health assessment is there to:

- Ensure that all new workers are medically fit to fulfil the duties and responsibilities of the job and consider adjustments that could be made to assist the person in the role.
- Assess whether the job may adversely affect the new worker's health, and whether any extra precautions are needed.
- Provide a record of health information as a starting point for comparison before work begins, such as a hearing test on a worker before beginning work in a noise hazard area to assess their baseline level of hearing.

The pre-placement assessment also offers the opportunity for new workers to:

- Understand their role more fully and be made aware of necessary precautions.
- Receive explanations regarding when personal protective equipment is needed, and how it is to be worn.
- Be introduced to the overall philosophy of health and safety in the organisation.

Some of the benefits of pre-placement evaluations include:

- Appropriate pairing of the applicant to the occupational requirements of the job.
- Discovery of health condition(s) that may place the safety or health of the applicant or others at risk.
- A basis for determining any reasonable aids or adjustments that are needed (for example, sensory aids, special workstations, additional devices, relocation of a workstation, and/or special parking).
- A baseline of health status so future measurements can determine whether any workplace exposures have proven detrimental to the worker's health.
- Knowledge of family health problems so advice on lifestyle changes can be provided, which can help reduce periods of worker absence, stress, or decreased productivity.

- A basis for relationship with the worker's supervisors regarding potential emergency situations (for example, insulin-dependent diabetes, convulsive disorders).
- Compliance with local legal requirements for certain job categories, such as primary education and health care.
- Measurement of psychological status so proper referral to counselling sources can avert future job-related stress.

Managing long-term sickness absence and capability (with reference to guidance NG146 produced by the UK's National Institute for Health and Care Excellence (NICE))

There is no commonly agreed definition of long-term or short-term sickness absence. The UK National Institute for Health and Care Excellence (NICE) guidance (NG 146) defines long-term sickness absence (including recurring long-term sickness absence) as absences from work lasting four or more weeks.

Initial Enquiries to be made by the Employer

Before 12 weeks (ideally after 2 to 6 weeks) after sickness absence began (or following recurring episodes of sickness absence), someone suitably trained (e.g. an occupational health physician, nurse, human resource specialist or the person's line manager) should contact the worker who has taken long-term sickness leave or recurring short- or long-term sickness absence and make initial enquiries regarding:

- The reasons for sickness absence
- Whether they have received appropriate treatment
- How likely it is that they will return to work
- Any perceived (or actual) barriers to returning to work (including the need for workplace adjustments)

The person should consider the worker's age, gender, and the type of work they do. These factors may affect their speed of recovery and ability to return to work. Also, consider any incentives or financial issues which may encourage or discourage a return to work (for example, any impact on pay).

If action is required, consider if a detailed assessment is needed to determine what interventions or services are required and to develop a return-to-work plan.

Detailed Assessment by the Employer

If the initial assessment has shown that a detailed assessment is needed, arrange for the relevant specialist to undertake it (or different aspects of it) with the worker. The detailed assessment could include one or more of the following:

- Getting further specialist advice on diagnosis and treatment or the need for further tests or sick leave.
- This could be achieved through a referral to an occupational health adviser, a GP with occupational health experience or to another health specialist such as a physiotherapist.
- Use of a screening tool to assess how likely it is the worker will return to work.
- A combined interview and work assessment.
- Deciding whether any interventions or services are needed.
- Developing a return-to-work plan.

Combined Interview and Work Assessment

This should involve one or more specialists and the line manager. It should evaluate:

- The worker's health and social and employment situation: this includes anything that is putting them off returning to work. For example, organisational structure and culture (such as work relationships) and how confident they feel about overcoming these problems.
- Their current or previous experience of rehabilitation.
- The tasks they carry out at work and their physical ability to perform them (dealing with issues such as mobility, strength, and fitness).
- Any workplace or work equipment modifications needed.

Return-to-Work Plan

The return-to-work plan should identify the type and level of interventions and services needed (including any psychological support) and how frequently they should be offered. It could also specify whether any of the following is required:

- A gradual return to the original job by increasing the hours and days worked over a period of time.
- A return to some of the duties of the original job.
- A move to another job within the organisation (on a temporary or permanent basis).

The meaning of Vocational Rehabilitation and benefits for the Worker and Employer Vocational rehabilitation is "a process that enables people with functional, psychological, developmental, cognitive, and emotional impairments or health conditions to overcome barriers to accessing, maintaining, or returning to employment or other useful occupation."

In simple language, vocational rehabilitation is whatever helps someone with a health problem to stay at, return to, and remain in work.

Vocational rehabilitation is directed to, and has the primary goal of, improving capability for work, and translating that into actually working. This may secondarily, in the longer term, lead to improved symptoms.

The concept of early intervention is central to vocational rehabilitation, because the longer anyone is off work, the greater the obstacles to return to work and the more difficult vocational rehabilitation becomes. It is simpler, more effective, and more cost-effective to prevent people with common health problems going on to long-term sickness absence. A 'stepped-care approach' starts with simple, low-intensity, low-cost interventions which will be adequate for most sick or injured workers and provides progressively more intensive and structured interventions for those who need additional help to return to work. This approach allocates finite resources most appropriately and efficiently to meet individual needs.

Examples (From Evidence to Community Practice in Work Rehabilitation)

Four examples illustrate that a range of vocational rehabilitation interventions in different settings can be effective for musculoskeletal disorders.

1. Prevention of long-term sickness absence in primary care:

A randomised controlled trial in Sweden showed that a cognitive behavioural intervention lowered the risk of long-term sick leave nine-fold, compared to a control group. The patients had lower back pain and perceived themselves at risk of long-term problems. The intervention comprised six sessions of group treatment by a therapist to change beliefs and behaviours so they could cope better with their problems. The control group had usual care.

2. Population-based model to improve return to work:

A randomised controlled trial in Quebec showed that workers who received a structured intervention combining clinical and occupational interventions returned to work 2.4 times faster than usual care. The subjects in a workers' compensation setting had been absent for longer than 4 weeks due to back pain. A six-year follow-up found that usual care generated some very costly cases because of long-term disability. The combination of work rehabilitation and workplace interventions at the sub-acute stage may provide important long-term savings.

3. Workplace-based intervention tackling obstacles to return to work:

A controlled trial in the UK showed that an early psychosocial intervention package, delivered at the workplace, improved return to work time from 10 days to 6 days. The subjects were workers with musculoskeletal disorders. The intervention package, delivered by occupational health nurses, addressed psychosocial obstacles to recovery through a supportive network that included advice, modified work, and communication with the GP. Modest benefits were achieved for low cost.

4. Educational intervention:

College lecturer Donny Gluckstein, a union representative with Scottish teaching union EIS (Educational Institute of Scotland), lost his voice. Filling in for absent colleagues and running an intensive course 'made me hoarse to the point where even speaking gently was painful,' he said. His GP confirmed he had 'aphonia' due to work-related overuse.

Armed with a sick note, he asked for 'reasonable adjustments' to be made at work. 'Being a union health and safety rep and health and safety lecturer and getting advice from the EIS health and safety official was very useful,' he said. Management responded positively, but even with the aid of a radio mike, laptop and projector, his voice became too weak to speak. He continued teaching, silently, with the help of portable whiteboards and the laptop.

Donny's voice only started to improve when he finally got to see an ear, nose, and throat specialist, who recommended exercise supervised by a speech therapist. He still uses the laptop and projector, has dropped intensive classes, and spreads his remaining classes over the week to avoid long periods of unbroken teaching. And he wanted to ensure others learn from his painful lesson. 'Our safety committee discussed voice care and management is already liaising with other local further education colleges,' he said. 'One teacher training college even asked me for advice on how to get voice training up and running. So the lesson is - don't suffer in silence. There is a duty of care and a lot that can be done for the most valuable tool in the teacher's toolbox - their voice.'

Benefits of Vocational Rehabilitation

Benefits include:

- Fewer staff days' absence due to illness (some studies have suggested between 20% to 60% reduction).
- Rolls Royce, having implemented an early intervention of rehabilitation programme estimated a saving of £11 million ("Vocational Rehabilitation: What Works, For Whom and When" (Waddell et al, 2008)
- Higher employment rates mean reduced welfare and taxpayer costs.
- Employers retain a skilled, trusted, and knowledgeable workforce.
- Workers who are working gain enhanced esteem.
- Workers who are working benefit from increased financial stability.

Possible barriers to ensure the effective that rehabilitation of workers

There is evidence to suggest that effective vocational rehabilitation depends on:

- Work-focused healthcare
- Accommodating workplaces

Both are necessary. They are inter-dependent and must be coordinated.

The concept of early intervention is central to vocational rehabilitation, because the longer anyone is off work, the greater the obstacles to return to work and the more difficult vocational rehabilitation becomes. For example, workers may be concerned that:

- Returning to work will adversely affect their condition
- They will not be able to cope with the job demands
- There will be no support for them
- Colleagues may not be sympathetic to their needs

To remove these, and other, barriers employers should:

- Have a rehabilitation policy
- Be able to offer suitable roles during the rehabilitation period
- Provide help and advice (such as an occupational health nurse)

What needs to be considered in a risk assessment prior to return to work.

It is important to review existing risk assessments before the person returns to work, or carry out new risk assessments. The work may be the primary cause of the sickness. In that case, it must be reported and investigated like any other work-related injury.

A revised risk assessment must identify what additional control measures are needed to prevent the ill-health from recurring. This should include identification of any job or organisational factors, which could prevent recovery or could worsen the condition.

Liaison with other disciplines in assessing and managing fitness for work with specific reference to existing health problems, fitness to work discrimination.

When workers have been absent for an extended period because of illness or injury, they are often able to begin doing some part of their work quite some time before they are fully fit to manage all their normal activities.

It is always better for people to keep in contact with their colleagues and their work as much as possible, rather than to be completely away from it for a long time, to prevent loss of familiarisation and to maintain their interest in ongoing projects. If people had to wait until they were fully able before returning to some work many would be absent for a long time. Returning to work after an extended absence is the beginning of a rehabilitation process, rather than the end of recovery.

An assessment of fitness for work includes the travel to and from, and activities carried out during work, the extent of the intrinsic demands of the work, and the necessary interactions with colleagues.

The decision to determine when an individual is fit to return to normal duties is usually a shared one. In some countries (such as the UK) a "Fit Note" is required from a doctor.

The Occupational Health staff can advise about how they believe the process may best be handled but cannot always judge how that may fit with the possibilities available to the manager. The recovery process is best agreed individually for each person and may involve temporary assignment to alternative work within the department, or a

graduated re-introduction to the normal assigned work. Such arrangements are always temporary, and it would be normal to review progress regularly with the person concerned. These arrangements should include a risk assessment (or a review of one) to ensure that the worker on rehabilitation is not exposed to increased health and safety risks.

Human Resources are often in the best position to judge the progress which someone makes if their work involves temporary secondment or assignment and should be able to discuss what alternatives may be available in other departments to assist a recovery programme. They also help to manage questions about salary structure and benefits, which may well arise during extended absence.

The role of agencies that can support employers and workers

Many countries have vocational rehabilitation (VR) agencies that help individuals to meet their employment goals, and employers to rehabilitate workers. In the US, each state has a VR agency to assist workers to gain employment.

In the UK, Job Centre Plus offers financial support for people unable to work and personalised help to help people find work. There is also a website called https://fitforwork.org. Fit for Work offers advice to anyone looking for help with issues around health and work.

These types of agencies can help individuals with physical or mental disabilities to obtain employment and live more independently through the provision support, such as counselling, medical and psychological services, job training and other personalised services.

The Construction Industry Advisory Council in the UK (CONIAC) aims to secure better Health and Safety outcomes in the Construction Industry including tackling occupational ill health and reports direct into the Health and Safety Executive (HSE).

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Occupational health services

The roles of typical occupational health specialists

The Occupational Health Physician

It is the occupational physician’s role to protect and promote the health and working ability of workers. They play a part in reducing the incidence of diseases and injuries, alleviating suffering, and promoting and protecting people’s health throughout their lives. The occupational physician is an expert adviser, sometimes part of the enterprise’s senior management team, who can assist in planning and reengineering the work process with regard to health and safety, legal requirements, good business and human resources practice.

The prime responsibility for the health and safety of workers rests with employers.

The occupational physician may work as part of an integrated multidisciplinary occupational health and safety service, or may have access to multidisciplinary colleagues in such a way as to enable the giving of appropriate advice in related fields of health and safety. Thus the occupational physician cooperates with many professionals inside and outside medicine, within the broad disciplines of health and safety, especially with senior management, legislators and government. If physicians are to make a maximum contribution to workers’ working ability and health

and safety at work, there must be proper arrangements in place to ensure they are competent. Professional competence is acquired through education, training, and experience. In the United Kingdom, specialists in occupational medicine uniformly undergo academic and practical on-the-job training under the guidance of university academic departments and hospital-based clinical units, and the Faculty of Occupational Medicine (FOM)

The Occupational Health Nurse

The Specialist Occupational Health Nurse is a fully trained Registered Nurse who, in addition to their general nursing education and training, will have undertaken an additional period of formal study in occupational health, leading to a recognised specialist qualification in occupational health nursing, most often at University degree level. The role of the specialist occupational health nurse is primarily orientated towards:

- The prevention of occupational injury and disease through a comprehensive pro-active occupational health and safety strategy.
- The promotion of health and work ability, by focusing on non-occupational, workplace preventable conditions that, whilst not caused directly by work, may affect the workers' ability to maintain attendance or performance at work, through a comprehensive workplace health promotion strategy.
- Improving environmental health management, by reducing risk to the working population and the wider community, which contributes to the wider public health agenda.

Occupational health nurses are the single largest group of health care professionals involved in workplace health management in Europe. In some European Member States, occupational health nurses are required by legislation. Even in those countries where there is no specific legal requirement to provide occupational health, such as in the UK, the practical nature and level of expertise required to deliver high quality occupational health services, to large populations, means that large numbers of occupational health nurses are involved.

The Occupational Health Technician

It is estimated that there are between 5,000 and 7,000 registered OH nurses practising in the UK alone, and demand from employers for OH advice and support has long been outstripping supply.

This is where OH technicians (OHTs) are, increasingly, getting involved. There are no firm statistics as to how many technicians there are. This is because an employer often directly trains an existing worker to take on various basic OH responsibilities. For OH practitioners practising in a multidisciplinary environment, the added value that properly supervised technicians can offer in terms of managing demand and easing workload is increasingly being recognised. OHTs are also sometimes called OH Support Workers.

To an extent, if all an employer wants is basic OH health surveillance, then a properly supervised technician could be one answer. However, the key is in the words "properly supervised". An employer also needs to recognise that if they go the extra mile and take on a registered OH practitioner it will give them the flexibility to offer more to their workers.

The (UK) Royal College of Nursing's 2011 guidance "Roles and responsibilities of occupational health support workers" outlines the definition and parameters of the OH technician or support worker role, the need for competency in health and safety, the importance of clinical audit, the education and career pathways of these sorts of roles and the supervision of OH support workers.

The guidance emphasises that technicians and support workers "will work under professional supervision within the guidance of established protocols and procedures".

In an OH setting, the role is likely to include agreed health screening and surveillance, health education and collection of health data that contributes towards the assessment of health risk arising from any work activity.

Dependent on the level of the technician (the UK has three grades - 1, 2 and 3) responsibilities can be to:

- Measure blood pressure, pulse, height, and weight, including Body Mass Index
- Do urinalysis
- Interpret new starter questionnaires
- Do audiometry
- Measure visual acuity to occupational standard
- Measure colour vision to occupational standard
- Do lung function testing to include peak flow and spirometry
- Assess mobility
- Do drug and alcohol testing
- Keep records
- Use communication and IT skills
- Venepuncture
- ECG
- Interpretation of food handler questionnaires
- Chester step test
- Skin assessment
- Hand Arm Vibration Syndrome (HAVS) Assessment to level 1 and 2
- Occupational health hazards and risk management

Occupational Health Adviser

The adviser will have similar qualifications in Occupational Health. They are not a qualified doctor or physician, but sometimes they are a qualified nurse. There is often some overlap with the responsibilities of an OH nurse.

The main role of the adviser is to provide good quality advice and support to the organisation's management. This means liaising with workers and managers, and giving advice on how to manage health problems. OH Advisers also take on a strategic role, and help formulate the organisation's vision for OH management. If the Senior Management agree with the vision, the OH Adviser then creates and implements the plans to bring that vision to life.

Typical activities offered by an occupational health service:

Typical activities offered by an OHS include:

- Health promotion
- Health assessment
- Advice to management
- Treatment services
- Medical and health surveillance

Health Promotion

Health promotion is the provision of advice on how to remain healthy whilst at work, including personal lifestyle factors such as diet, exercise, smoking, etc.

To be successful, workplace health promotion must have the participation of workers, management, and other stakeholders in the implementation of jointly agreed initiatives and should help employers and workers at all levels to increase control over and improve their health.

While some health promotion activities in the workplace tend to focus on a single illness or risk factor (e.g. prevention of heart disease) or on changing personal health practices and behaviours (e.g. smoking, diet), there is a growing appreciation that there are multiple determinants of workers' health. In addition to person-focused interventions, workforce health promotion initiatives have moved toward a more comprehensive approach, which acknowledges the combined influence of personal, environmental, organisational, community, and societal factors on worker well-being. A health-promoting workplace recognises that a healthy workforce is essential to the success of the organisation.

Health Assessment.

There are a number of types of health assessment that might be carried out in a workplace.

- **Fitness for Work:** The primary purpose of health assessment fitness for work is to make sure that an individual is fit to perform the tasks involved effectively and without risk to their own or others' health and safety. It is not the intention to exclude a person from a job but to make any necessary reasonable modifications or adjustments to the job to allow the person to work efficiently and safely. An assessment may be required when:
- The individual's health condition may limit or prevent them from performing the job effectively (e.g. musculoskeletal conditions that limit ability).
- The individual's condition may be made worse by the job.
- The individual's condition may make certain jobs and work environments unsafe to them personally (e.g. liability to sudden unconsciousness in a hazardous situation, risk of damage to the remaining eye in an individual with monocular vision).
- The individual's condition may make it unsafe both for themselves and for others in some roles.
- **Employment health assessment:** In some countries (such as the UK and the Equality Act 2010) it is illegal for prospective employers to ask questions or issue health questionnaires as part of the recruitment process. Employers are still permitted to make job offers conditional on satisfactory health checks. Therefore, employers may still ask health-related questions and require workers to undergo medical checks once a job has been offered. This health assessment may lead to the organisation making reasonable adjustments to the person's work or workplace.
- **Return to work**. A well-managed early return to work will reduce the risk of the absence becoming long-term (long-term is defined as an absence period of longer than one month). In general, people find it more difficult to return to work after a long-term absence. Encouraging a speedy return to work is linked with a number of activities that are recognised as good practice in terms of early return to work. These actions include:

    - Keeping in regular contact with the worker. Regular contact helps to keep work on their agenda and offers good opportunities to plan the return to work. Someone will need to keep in contact and have regular discussions about progress.
    - Reviewing the situation. The worker needs to regularly review their situation with their doctor.
    - Return to work discussions. A return-to-work discussion with the person may help to identify what caused them to go off work and what adjustments their manager needs to make. The person may

find it hard to talk about these issues. Talking to the worker about these to see if any adjustments at work will help.
    - Staged return. When the worker feels ready to return to work, a 'staged return', for example, working part-time hours for the first few weeks - can help ease them back into their work.
- **Job-related medical screening:** This is a means of ensuring that workers do not have a health condition that could be detrimental to them carrying out a job or certain tasks. An example may include: uncontrolled diabetes or epilepsy would cause problems for workers who may have to drive or work at height.

Pregnant workers

Pregnancy is not an illness, but working conditions normally considered acceptable may no longer be safe during pregnancy and breastfeeding. In many workplaces, there are risks which may affect the health and safety of new and expectant mothers and that of their child.

A new and expectant mother may be defined as someone who:

- Is pregnant
- Has given birth within the last six months
- Is breastfeeding

OHS can assist in the risk assessment process that should be undertaken by the employer when the pregnancy becomes known, and in recommending control measure or job adjustments. For example, reduced hours, temporarily stopping shift work, removal from contact with certain hazardous agents.

ASPECT OF PREGNANCY:	Factors in work:
Tiredness	• Overtime • Evening work • Night work
Morning sickness	• Early shift work • Exposure to nauseating smells
Backache	• Standing e.g. theatre • Manual handling • Posture
Varicose veins	• Standing • Sitting
Haemorrhoids	• Working in hot conditions
Frequent visits to the toilet	• Difficulty in leaving lob • Inadequate facilities in site of work

Examples of considerations in an expectant mother risk assessment (Taken from UK HSE Guidance)

Things to be considered during the assessment include:

- **Physical risks:** such as noise, vibration, and radiation.
- **Chemical/Biological risks:** toxic chemicals, infectious diseases, mercury, and lead.
- **Working conditions:** heat and cold extremes, work-related stress, and rest facilities.
- **Lifting and handling:** pregnancy has significant implications for manual handling.
- **Sitting or standing**: continuous standing during the working day may lead to dizziness, faintness, and fatigue.

Advice to Management

OHS specialists can provide organisation management with the expert advice that they need to enable them to take decisions to protect the health of the workforce. That advice might include:

- Having an input to risk assessments where health issues are involved.
- Advising on health policy (such as smoking policy, or drugs and alcohol policy) and advising of promotion campaigns.
- Absence management: how best to tackle high absentee rates, including counselling and return to work interviews.

Treatment Services.

Many workplaces, especially large organisations, offer a range of treatment services to the workforce, including:

- **First aid:** treatment for injuries sustained during work-related activities (often a legal requirement) often with not only trained first aiders available, but also occupational physicians and nurses.
- **Dental and Physiotherapy services:** designed to offer workers a service which, if not offered, may mean workers taking time off to get the treatment. Physiotherapy, for example, may be used to treat workers suffering from, sprains, strains, or back injuries which may otherwise keep them off work.
- **Counselling:** The occupational health professionals can provide support using counselling and reflective listening skills. This requires appropriate psychotherapeutic training. The occupational health team, because of their unique knowledge of the individual worker, the type of work and the organisation, can identify where intervention might be of benefit. Their position of trust provides a point of contact for the individual who has personal problems that may affect their ability to work effectively.

Their specialist knowledge of the potential hazards and risks within the workplace enables them to assess, and give advice in, situations such as:

- Workplace stress
- Drugs and alcohol abuse
- Bullying and harassment
- Violence and aggression
- Sickness and absence assessment
- Health surveillance

Medical and Health Surveillance

Whereas occupational health surveillance concerns the ongoing, systematic collection, analysis and dissemination of exposure and health data on groups of workers for the purpose of preventing illness and injury, medical surveillance describes specific activities that target health events or a change in a biological function of exposed persons.

In the ILO Code of Practice "Safety in the use of chemicals at work", Regulation 13 concerns Medical and health Surveillance. It states:

- Medical surveillance, conducted by an approved medical practitioner, should be used as part of overall health surveillance, in accordance with the objectives and principles of the Occupational Health Services Recommendation, 1985 (No. 171). Health surveillance should also include, where appropriate, simple techniques for the early detection of effects on health. These could include examination and questioning about health complaints.

- In the case of exposure of workers to specific hazards, medical and health surveillance should include, where appropriate, any examination and investigations which may be necessary to detect exposure levels and early biological effects and responses.

Medical surveillance is necessary where:

- it is required by national law whenever workers are liable to be exposed to chemicals hazardous to health; or
- the employer is advised by an occupational health service that it is necessary as part of the protection of workers exposed to chemicals hazardous to health, given special attention to pregnant and breastfeeding women and other susceptible workers; or
- atmospheric or biological monitoring show that there could be effects on the health of a worker because of exposure to chemicals at work and medical surveillance will assist early detection of ill effects.

Exposure to the following chemicals may be appropriate for:

- Chemicals that have a recognised systemic toxicity, i.e. an insidious poisonous effect
- Chemicals known to cause chronic effects, e.g. occupational asthma
- Chemicals known to cause severe dermatitis
- Chemicals that are known or suspected carcinogens
- Chemicals that are known or suspected teratogens or mutagens, as science develops
- Other chemicals where there is a likelihood that the disease or effect may occur under particular conditions of the work activity

ILO Code of Practice "Ambient factors in the Workplace" also specifies health and medical surveillance requirements for workers potentially at threat from occupational ill- health and disease.

9.2: Mental ill-health

Occupational circumstances that could lead to workplace mental ill-health issues

Introduction

Mental health (sometimes referred to as 'emotional health' or 'wellbeing') is just as important as good physical health.

Mental health is about how we think, feel, and behave. Anxiety and depression are the most common mental health problems. They are often a reaction to a difficult life event, such as bereavement, but can also be caused by work-related issues.

According to the World Health Organization (WHO), over 260 million people suffer from depression globally. It says that 'work is good for mental health but in a negative working environment this can lead to physical and mental health problems'.

WHO goes on to state that 'harassment and bullying at work are commonly reported problems, and can have a substantial adverse impact on mental health'.

A common misconception is that mental health problems are only caused by 'home' issues, so some employers can feel that it's not appropriate, or their responsibility, to intervene and provide support to employees.

It is more common that the cause of an employee's mental health problems is a combination of issues relating to both their work and private lives.

Occupational circumstances that could cause or contribute to mental ill-health include:

- Lone working and home working - leading perhaps to a feeling of "isolation".
- Shift working – as a result of varied schedules or night shifts, sleep depression may contribute to mental ill-health issues.
- Workers who are subjected to workplace aggression, violence, bullying or harassment.
- Organisational change – leading to uncertainty and worry over job security.
- Having to work a second job – because of accumulated debt, or limited guaranteed hours in the main hours (some workers in the UK have "zero guaranteed hours" contracts).

The impact of chronic pain on a worker's mental health

Research has shown that mental health disorders and chronic pain are each associated with work disability. Mental health disorders are more highly associated with some work disability outcomes when accompanied by chronic pain, especially in women.

The severity of chronic pain has been associated with depression, with the presence of both chronic pain and depression giving rise to possible with greater emotional distress, poorer health-related quality of life, and decreased physical functioning relative to those with only one of these conditions.

Depression and Anxiety

Depression is "when you have feelings of extreme sadness, despair or inadequacy that last for a long time". (UK NHS definition).

Anxiety is "an unpleasant feeling when you feel worried, uneasy or distressed about something that may or may not be about to happen". (UK NHS definition.)

Depression

Depression is a mood state that can significantly impact an individual's entire life. Major depression is a condition that goes far beyond feeling sad or upset.

Depression affects a person's mood, thoughts, feelings, behaviours, and physical health. Severe depression can result in losing the ability to feel pleasure in formerly-enjoyable activities and/or social relationships.

People struggling with depression struggle with a loss of energy and motivation which can negatively influence the ability to be productive at work or school. Depression, notably untreated depression, is a major risk for suicide due to the deep despair and hopelessness depression causes. Suicide may feel like the only way to escape the pain.

Many potential causes for depression exist. It can be genetic, meaning the patient has a family history of depression. Personal trauma and sources of stress, such as a failed relationship or a lost job, can also cause depression. Social isolation as the result of conflict with family and friends can be a contributory factor, and certain medications, such as high blood pressure medication, have depression listed as a possible side effect.

Emotional symptoms of depression include:

- Withdrawal from socialising
- Loss of interest in previously enjoyed hobbies

- Constant irritability or sadness
- Constant pessimism
- Feelings of inadequacy and self-loathing

Physical symptoms include:

- Erratic sleep habits
- Loss or increase in appetite
- Constant fatigue
- Muscle aches
- Headaches

In the short-term, depression is likely to cause loss of appetite, weight loss, and other physical symptoms. If you develop insomnia or hypersomnia (sleeping too much), you will be fatigued and lethargic. In the long term, you can experience malnutrition from not eating enough or become obese from eating too much. You can also experience a drop in short-term memory, finding it easier to forget things. Long-term depression can also lead to suicide.

Anxiety

Anxiety is a word we use to describe feelings of unease, worry, and fear. It incorporates both the emotions and the physical sensations we might experience when we are worried or nervous about something. Although we usually find it unpleasant, anxiety is related to the ‘fight or flight’ response (our normal biological reaction to feeling threatened.

We all know what it’s like to feel anxious from time to time. It’s common to feel tense, nervous, and perhaps fearful at the thought of a stressful event or decision you’re facing. Especially if it could have a big impact on your life. For example:

- Sitting an exam
- Going into hospital
- Attending an interview
- Starting a new job
- Being diagnosed with an illness
- Deciding to get married or divorced

In situations like these it’s understandable to have worries about how you will perform, or what the outcome will be. For a short time, you might even find it hard to sleep, eat or concentrate. Then usually, after a short while or when the situation has passed, the feelings of worry stop.

Because anxiety is a normal human experience, it's sometimes hard to know when it's becoming a problem. But if your feelings of anxiety are very strong, or last for a long time, it can be overwhelming.

For example:

- You might find that you’re worrying all the time, perhaps about things that are a regular part of everyday life, or about things that aren’t likely to happen. Or even worrying about worrying.
- You might regularly experience unpleasant physical and psychological effects of anxiety, and maybe panic attacks.
- Depending on the kind of problems you experience, you might be given a diagnosis of a specific anxiety disorder.

If anxiety is affecting your ability to live your life the way you'd like to, it's worth thinking about ways to help yourself, and what kind of treatments are available.

The effects of fatigue on mental health

Mental fatigue is a condition triggered by prolonged cognitive activity. Basically, it sends your brain into overdrive, leaving you exhausted, hampering your productivity and overall mental processing ability.

Common symptoms include mental block, lack of motivation, irritability, loss of appetite and insomnia. Mental exhaustion can have both a long or a short-term impact.

The meaning of work-related stress and its relationship to mental health conditions

Work-related stress can be defined as:

"the adverse reaction people have to excessive pressures or other types of demand placed on them at work" – (UK HSE Definition).

Work-related stress and mental health problems often go together, and the symptoms can be very similar.

Work-related stress can aggravate an existing mental health problem, making it more difficult to control. If work-related stress reaches a point where it has triggered an existing mental health problem, it becomes hard to separate one from the other.

Common mental health problems and stress can exist independently – people can experience work-related stress and physical changes such as high blood pressure, without having anxiety, depression or other mental health problems. They can also have anxiety and depression without experiencing stress. The key differences between them are their cause(s) and the way(s) they are treated.

The causes of work-related mental ill-health relating to organisation, job and individual

The causes of work-related mental ill-health are always linked to one of three factors:

- The organisation
- The job
- The individual

Work-related mental ill-health is often caused by a combination of stressors, some of which at least are work-related. These include:

- The organisation of work
- The workplace culture
- The working environment
- The job content
- The job role
- Relationships at work
- The home-work interface

The Organisation of Work

The organisation of work includes stressors such as the working hours and shift patterns. The way shift patterns are organised can be inherently stressful if they do not allow individuals to sufficiently rest, or if they disrupt natural sleep patterns. The shifts may be too long, requiring people to work many hours per day.

Some professions, such as restaurant workers, have a very long working day. They may start work in the morning to prepare for lunch, cook and serve food over lunch. Then take a long break in the afternoon (several hours), and then do it all again for dinner and finish late in the evening. This constant requirement for long days can be very demoralising if there is no prospect of change in sight.

Some working arrangements may have unpredictable hours. For example, zero-hour contracts where there is no guarantee of work. Instead, hours can change every day, and workers can be called in at the last minute for emergency cover. Some organisations have a culture of changing working hours frequently, causing significant disruption to people's personal lives which are organised around worktime (for example, childcare arrangements).

Workplace Culture

Cultural problems can encompass several issues.

Communication is an important factor. The lack of, or unclear, communications and information can be a significant stressor. People instinctively prefer to understand what is happening around them and why. If the management of the organisation does not communicate this, there can be significant uncertainty about what will happen in the future. Poor communication between departments can also lead to disruption and inefficiencies. Situations where one department does not know what the other department is doing, and their work interferes with each other, are commonplace. These can lead to significant interpersonal friction between department members and managers.

There may be a lack of a formal communication system to raise issues from the workforce to management. Workers may not know who to report problems to, for example, safety concerns or bullying. Even if a formal system exists, if management fails to listen and act on these concerns, the workers will be left with a problem to address themselves.

The structure of the organisation can be a source of stress. Some organisations have a very flat structure, others very tall. With flat structures, there can be improved communication between the workers and senior management, but far fewer managers in the organisation. This is seen by most as a good thing. But it also means that those managers have more people and activities to manage, which can lead to them being overloaded with work.

Changes in the structure of the organisation may also be stressful. Organisational restructuring often leads to job losses, with entire layers of management, functions, or departments eliminated. Those who survive the change may find that their job role changes significantly, having to take on additional duties from those who have left the company. This means they must learn new skills and have a greater workload than before.

Some organisations are very supportive and provide their workers and managers with the resources they need to get the job done. This is obviously a good thing in terms of stress. When resources (such as time, money, equipment, people, skills, expertise, etc.) are unavailable or limited, some jobs may not be completed. Since the resources to carry out all tasks are unavailable, it becomes a matter of deciding and prioritising which tasks should go ahead. But the organisation will still apply pressure to complete all the work. This causes stress and friction.

Workplace Environment

Environmental issues such as noise, space, uncomfortable temperatures, and poor levels of lighting, all contribute to stress. Noise can be a significant distraction. There is an old expression in English: "I cannot hear myself think!".

Where noise levels are high, or very distracting (such as high pitch sounds), it can become difficult to communicate or think clearly.

Space is lacking in most workplaces. This leads to materials and equipment being stored wherever space can be found, instead of where it should be. Much of the working day gets taken up by managing the available space and moving things around so everything can fit. This takes time and therefore increases the workload. Lack of space is also inherently stressful. Humans like space to move around comfortably. We like to be able to find and get things easily.

Job Content

Workload is an obvious potential stressor. When the demands placed on us are in excess of what we are capable of delivering, we will feel under pressure. Certain professions have very high workloads, such as doctors, nurses, social workers, and teachers. These high workloads lead to long working hours, and the feeling that there are "not enough hours in the day". Stress levels in these professions are high.

Linked to the workload are time pressures. When the time provided to complete a task is too short, the worker is under pressure and is fighting the clock. Shortcuts get taken. Taking shortcuts is often not malicious. The worker just wants to get the job done in the time available. Often, this leads to a low-quality performance, and the worker realises this and feels demoralised. Call centre agents are often given strict targets to reduce the time they spend on the telephone with customers, to process as many calls as possible. This can lead to poor relationships with customers, and call centre agents feeling demoralised as a result.

Boredom can be very stressful. Some workers have a higher aptitude or capability than the job they are doing. They want to do more interesting work, which requires more thinking and use of their brains or other skills. If they are stuck in a job which is too easy or is not demanding enough, they can feel wasted and demotivated. This is the opposite of excessive work demands. Whilst some workers are very glad for an easy job, others are more ambitious and like to be challenged.

Job Role

Clarity over the roles and responsibilities of people and departments is important. One major frustration at work is where everyone claims that a particular problem is not their job to fix. Alternatively, there are situations where one department expects another to do something, but that department does not believe it is their role to do it. This can lead to serious friction and worsening relationships. Individuals also like to be clear on their own roles and responsibilities, since they want to know what the boundaries of their behaviour should be. Some people can get anxious without this clarity, since they will not know how they should behave, or what decisions they are empowered to make.

The way roles and responsibilities are structured can sometimes lead to conflicts of interest, especially between different departments. If the Production department is given no responsibility for the quality of the materials they produce, this will lead to disagreements with the Quality department. Unfortunately, the Quality department is not responsible for producing the materials, and therefore has no control over the process. When the organisation decides on what each department's responsibilities are, and what their individual targets should be, they should consider these potential conflicts and ensure that different departments share the same overall goals. Both Quality and Production departments should be responsible for getting materials made, on time, and to the correct quality standard.

Individuals can also have a personal conflict of interest. A Construction Site Manager may be under considerable pressure to finish a project but is also responsible for the safety of the workers. There is a conflict: finish the work on time, but take unacceptable risks to safety? Or finish the work late, and follow the standard safety rules? It becomes a difficult decision, especially when there is a lack of support or resources from senior management. Without the support or clear guidance from senior management, the Construction Site Manager makes the best decision they can, but risks taking blame if things go wrong.

Humans like to be in control of their work. They like to control what they do, when they do it, and how they do it. Unfortunately, many industries do not allow the workers to take any control. Manufacturing commonly uses conveyor belts, which operate at a fixed speed. The workers must keep time with the conveyor. The conveyor is in control, not the worker. The worker does not get time to take a second's rest, they cannot slow or stop the machine if they need to go to the toilet. Other jobs are very prescriptive in how the work is carried out. The financial services industry is very regulated in certain countries, to the point where financial advisers are given strict scripts to control what customers are told. Customers are forced to listen to long legal monologues from advisers. Neither the adviser nor the customer enjoys this, and it leads to considerable unhappiness for some advisers who crave to have more flexibility.

Relationships

Most jobs involve working with others. Where relationships are positive, constructive, and fun, work can be almost a pleasure. However, where relationships are negative, pressure and stress will ensue.

Bullying and harassment are two of the most damaging relationship stressors. Whilst bullying is mainly associated with schoolchildren, it is surprisingly common amongst adults at work.

Bullying is any behaviour that is unwanted, offensive, or uninvited. It can take many forms. Examples are:

- Personal attacks from one colleague to another
- Spreading rumours, or lies, about a colleague
- Yelling, name-calling, mocking or subjecting to ridicule. Even if the bully perceives it a "just a joke" or "just a little fun"
- Unwanted gestures, or comments
- Carrying out unwanted actions, such as placing unwanted images or objects on someone's desk or in their locker

Managers have authority over an individual, and therefore if they bully a subordinate, the effect can be even more damaging.

- Not providing a worker with the support or resources they need to complete a task, and then holding them responsible for failure (setting someone up to fail)
- Not providing any feedback on performance
- Treating the worker negatively, and their colleagues positively, even where performance is similar
- Withholding essential information
- Micro-managing their performance, or monitoring them excessively
- Holding them to a higher standard of behaviour or performance than their colleagues
- Excessive or conflicting work expectations
- Public humiliation, insults
- Unwarranted criticism, blaming

Bullying and harassment are very similar, with the exception that harassment is linked to discrimination and is on the basis of differences in age, sex, disability, race, religion, or sexual orientation.

The most extreme forms of poor working relationships are where these degenerate into verbal or physical abuse. These result in strong emotions, such as anger, fear, a perception of persecution, and shame.

Home-Work Interface

This refers to several issues where work causes difficulties at home.

One of the most common problems is the lengthy travel time to and from work. It is common for workers to add many hours to their day in commuting. Not only is this tiring, but it has the impact on family and personal time. Parents see their children for only a short time a day and have little or no time for personal activities such as exercise or studying. The constant routine of lengthy commutes can be very demoralising in the long-term.

When workers have young children, someone must look after them during the day. Even older children need supervision before and after school hours. Childcare needs to be organised. Where family members are unable to assist, paid childcare assistance must be sought. In countries where childcare is a heavily regulated industry (such as the UK and some US states), this can make childcare very expensive. For single parents, the cost can be as high as 65% of their income. If the parent chooses to work, it can make work very demotivating knowing that 65% of their salary is lost.

In some cases, such as shift work or night work, paid childcare cannot be obtained. The parent then must choose: take time off work (and lose money, maybe even lose their job) or go to work and leave the children without supervision? It is a difficult decision and puts the parent under significant mental pressure. Working, whilst knowing children are at home unsupervised, can be very stressful. Their mind will be worrying and not focused on the job.

Some jobs require temporary or even permanent relocation. For example, the offshore industry can require people to work for several weeks or months in a remote location, on a ship or a platform. Migrant workers in the Middle East can spend months, or even years, away from their families. It is quite natural for them to miss their families, and this can lead to a growing loss of morale, affecting productivity. It is even more upsetting where there is some upsetting situation happening at home, such as an illness or injury, but they are unable to return to assist. Some companies take the issue very seriously, and provide lots of entertainment, counselling, and even carry out anti-suicide initiatives such as putting away ropes at the end of the shift.

Combinations of Stressors

It must be recognised that mental ill-health in the workplace is rarely entirely due to work-related factors. Instead, a combination of work and personal factors is often involved. Personal issues that can contribute can include:

- Bereavement and loss
- Relationship breakdown
- Financial problems
- Caring for sick or disabled children and/or elderly parents
- Personal or family illness

Work-related stress and poor mental health often go together. The symptoms of stress and common mental health problems are similar, for example, loss of appetite, fatigue, and tearfulness can be symptoms of both.

Work-related stress may trigger an existing mental health problem that the person may otherwise have successfully managed without letting it affect their work. Most people have some sort of emotional baggage from their past. Often, work situations trigger previously repressed feelings, thoughts, and emotions. Whilst work is the trigger, work did not cause the original baggage. A person without that emotional baggage would react very differently to the same situation.

For people with existing mental health issues, work-related stress may worsen their problem. If work-related stress reaches a point where it has triggered an existing mental health problem, it becomes hard to separate one from the other.

Mental health controls

Working together to manage mental ill-health conditions

Managing mental ill-health in a workplace requires a team effort. The occupational health professionals should work closely with the human resources (HR) people and line managers with regards all mental (and physical) health of workers. Line managers have a key role to play in recognising potential problems at an early stage. The occupational health team should look at the effects of health on work or of work on health and discuss with workers any health problems they may have with a view to promoting good health through health education, screening, and action programmes.

One role of HR professionals is to ensure that workers with mental ill-health issues feel comfortable in their place of work and are made to feel part of the team. HR people provide a critical link between the workers and line managers, by assisting line management to manage staff who are experiencing problems at work.

Contributors to mental ill-health issues may be from problems outside of the work environment. HR should monitor this because, good organisations recognise that their responsibility for workers wellbeing doesn't start and end at work.

Working Effectively with Mental Health Problems

The workplace is an appropriate environment in which to educate individuals about and raise their awareness of mental health problems. For example, the workplace can promote good mental health practices and provide tools for recognition and early identification of mental health problems and can establish links with local mental health services for referral, treatment, and rehabilitation.

Ultimately, these efforts will benefit all by reducing the social and economic costs to society of mental health problems.

With support from their employer, most people can continue to work effectively despite their mental health problems.

Identifying and Assessing Work-Related Mental Ill-Health

The earlier you notice that a worker is experiencing mental health difficulties the better. Early action can help prevent the worker becoming more unwell.

Line managers can play a key role in identifying and addressing barriers to normal working life rather than trying to understand the diagnosis. If a worker is already off sick, lack of contact or lack of involvement from the manager may mean they feel unable to return.

Involvement and reassurance at an early stage minimises the risk of not returning to work and the difficulty of resolution.

Health and Safety Practitioners have a wide range of tools at their disposal to identify potential work-related risks to mental health, and the extent of the problem.

Formal and Informal Discussions

Formal and informal discussions can be held with a wide range of people in the organisation, to ask for their views on the level of demands imposed on workers, and their thoughts on whether the resources and support provided is sufficient. These discussions could be in a group setting or one-to-one. It is important that individuals feel safe, to be honest, and contribute. The feedback should generally be anonymous, without fear of reprisal.

The Performance Appraisal process, a common annual discussion between the individual worker and their manager, is also a useful source of information. These conversations are often an honest and open dialogue about how the worker is performing, how they are feeling, what they want to achieve in the future, and what support they need. This information is then shared with the Human Resources department who collate the data into a useable format.

Health and Safety Committee meetings may raise the issue of stress as a point of concern. It may also be discovered as a cause of an accident or incident, during an investigation.

Absence Data

The Human Resources Department of larger organisations usually has access to data on sick leave and the reasons given. Whilst they may be somewhat reluctant to share personal details which identify the people who are sick, they will be able to provide data such as:

- Numbers of people and total days taken as sickness.
- Proportion of these that have been declared as due to a mental health reason.
- Departments or teams where these individuals work.

This data will help to provide an overall view of the potential size of the problem.

Interviews.

Return to Work interviews are an important source of information.

Many companies operate a Return-to-Work interview procedure, where a worker is interviewed by their manager after a sickness absence. This interview aims to identify the causes of the sickness, whether it was work-related in any way, and what support the worker now needs on their return.

If the worker declares that they are feeling depressed, anxious, or stressed, it is important that the manager probes to discover the cause of this. If there is a suspicion that the mental ill-health is at least partly caused by work, this should trigger an investigation from the Health and Safety team.

Surveys and Questionnaires

Paper or online surveys are useful tools, to ask workers questions about their work and how they feel.

The information gained can be analysed, to see which areas are the cause for most concern.

Surveys can probe issues such as clarity of job roles, levels of support, whether workloads are manageable, etc.

The UK's HSE has several useful stress survey tools, including a two-page questionnaire for workers, and an analysis tool to analyse the results.

The types of interventions for mental ill-health

Primary prevention

Clearly, the preferred option is to stop mental health problems before they occur, including the promotion of "good mental health for all". Often primary prevention work is 'universal' in that it targets and benefits everyone in a community. The UK Mental Health Foundation hosts an annual "Mental Health Awareness week". The 2021 theme is "Nature and the Environment. "The evidence is clear that access to nature is crucial for our mental health as evidenced by the many global lockdowns experienced by millions as a result of Covid-19.

Secondary prevention

Secondary prevention involves offering support to those at higher risk of mental health problems (either because of biological characteristics they are born with, experiences they have had or circumstances that people find themselves in – such as lockdowns.) by providing targeted help and support. This type of prevention is often termed "selective" or "targeted" prevention. Examples include programmes which support those who have had traumatic experiences or been victims of bullying, harassment or hate crime.

Tertiary prevention

These types of programme usually focus on people who are already suffering from mental health problems. The aim is to reduce symptoms that can be disabling, and to empower people to manage their own symptoms where possible. Tertiary prevention is seen as complementary to treatment for mental health problems and is often carried out in community, rather than clinical, settings. In essence, tertiary prevention id about people living with mental health issues to stay well.

How workers with mental ill-health conditions can be managed in the workplace

Talking at an early stage

As a manager, you may have employees who experience mental health difficulties. As soon as you notice that an employee is having difficulties, talk to them – early action can prevent them becoming more unwell.

If the person does not want to speak to you, suggest they speak to someone else, for example someone from your employee assistance programme, occupational health team or their own GP.

Managers should concentrate on making reasonable adjustments at work, rather than understanding the diagnosis. Their GP, medical support or occupational health should be able to provide guidance on what you can do to help them.

If an employee goes off sick, lack of contact or involvement from their manager may mean they feel isolated, forgotten, or unable to return. You can reduce the risk of them not returning to work by:

- keeping them informed about what is going on, including social events
- reassuring them early on and throughout their absence

Using routine management tools to identify and tackle issues

Use scheduled work meetings, appraisals, or informal chats about progress to find out more about any problems an employee may be having. You could have health and safety as an agenda item at meetings. As well as things like display screen equipment assessments etc, this can be used for stress or mental health issues.

If you have specific concerns about someone's health, talk about these at an early stage. Ask questions in an open, exploratory, and non-judgemental way. These conditions affect people differently, so making adjustments to their job could relieve symptoms. You should be positive and supportive while exploring the issues and how you can help.

If a person has been off sick, you should discuss their return to work and reintegration into the workplace beforehand. A written plan can help. You both might want to agree when they have reached the stage of 'business as usual'. At this point, you can use existing management processes to review their performance, needs and work plan.

Support for emotionally distressed workers

If an employee gets upset, talk to them, reassure them, and tell them that you will give them all the help and support available. Explain that things will go at a pace that suits them. If you are in a meeting with them, ask if they would like someone else with them.

Try to be sensitive to the level of information the person can cope with. In the middle of a crisis they may not be able to think clearly and take in complex information. Try to stay calm yourself.

Problems can build up over time and while you may feel pressure to do something, it might be better to take some time to think about options properly. Agree with the person which issues are most urgent.

If the session is not helpful for the person or you, rearrange it for when they are less upset. If the problem carries on, you should encourage them to seek help, for example from occupational health or their GP.

A much smaller number of people will experience more severe anxiety or depression. These can be associated with episodes of 'mania', which can include:

- extreme, heightened activity
- psychosis
- loss of touch with reality
- hallucinations
- distortion of the senses

In these rare instances, an employee may behave in ways that impact on colleagues or clients and you should keep your responsibilities for all employees in mind.

Take the person to a quiet place and speak to them calmly. Suggest that you could contact a friend or relative or that they go home and contact their GP or a member of their mental health team, if appropriate. You may be able to make an appointment and go with them to the surgery, if they want you to.

Managing a person with an ongoing illness

Most people who have ongoing mental health problems continue to work successfully. But when someone needs support, managers can work with them to ensure flexibility to suit their health needs.

People with mental health problems should be treated in exactly the same way as any other member of staff, unless they ask for help or demonstrate clear signs that they need it. It is discriminatory to make assumptions about people's capabilities, their promotability or the amount of sick leave they may need because of their illness.

Coping strategies

Most people are encouraged to develop a coping strategy as part of their care. This often involves noting signs of a possible relapse and taking pre-emptive action, such as cutting down on work, being careful about drinking alcohol, taking exercise, and finding time to relax. It is important you support the employee at this first warning stage. Small, inexpensive adjustments may well prevent a more costly period of illness.

Advance statements

Some people find it useful to draw up an 'advance statement' which explains how they want to be treated if they become unwell. The statement can cover practical arrangements such as details of the people who need to be contacted or provided with information.

It might be helpful to draw up an advance statement which relates to the workplace. It could include:

- signs that indicate the person is becoming unwell
- who to contact (perhaps a close relative, care coordinator or GP)
- what sort of support is helpful and what is not

If an employee draws up an agreement with you, you should put the statement into practice to maintain trust.

Guidance and support

There are specialist organisations that can provide guidance and support outside the workplace. The employer should ensure that workers know where, if necessary, they can get this help and support. For example, in the UK, there is outside assistance and support for workers who have suffered bereavement; domestic violence; emotional crisis or social welfare issues.

The benefits of good nutrition, exercise, and sleep on mental ill-health conditions

The mind and the body are connected in many ways. It therefore makes sense that the way in which we look after our bodies can impact our mental health.

Research from the MIND charity suggests that the majority of people who don't suffer from daily mental health problems eat fresh fruit (or have fruit juice) every day. It is similar for those who eat fresh vegetables and salad daily. Those who eat healthy foods however, including junk food like chips and ready meals, report higher levels of mental health problems.

Research suggests that for exercise, we need to do cardio (brisk walking or running) at least three times a week. Other forms of exercise can benefit health as well. For example, yoga can be a great resource to manage stress.

However, an important component of managing a healthy lifestyle is rest. If you don't take at least one day off each week, it can hurt your body more than it will help.

Sleep is important for optimum mental and physical health. In particular, regular patterns of sleep at regular times. Research has shown a connection between sleep problems (particularly insomnia) and depression.

The UK HSE stress management standards

The UK HSE identified seven broad categories of risk factors for work-related stress.

- Culture issues, which could include lack of positive response to stress or health concerns, lack of staff involvement, poor communication, lack of consultation and participation in decision making, and long work hours or lack of rest breaks.
- Demands such as lack of challenge and pressure, exposure to violence or aggression, work overload, poor physical environment, lack of training, lone working, and fast pace of work.
- Control issues which as a low level or lack of control over task design, or non-participation in decision making.
- Relationships with those working with them. This can range from bullying and harassment, through lack of support for the worker to physical violence.
- Change - this could include changing market demands, new technology, and organisational restructuring.
- The individual's role, and conflicts and ambiguity within it.
- Support, training, and individual factors such as lack of adequate training, a mismatch between person and job, lack of support or feedback, and lack of constructive advice.

The HSE went on to develop "The Management Standards", which define the characteristics, or culture, of an organisation where the risks from work related stress are being effectively managed and controlled.

The Management Standards cover six key areas of work design that, if not properly managed, are associated with poor health and well-being, lower productivity and increased sickness absence. In other words, the six Management Standards cover the primary sources of stress at work. These are:

- **Demands:** this includes issues such as workload, work patterns and the work environment.
- **Control:** how much say the person has in the way they do their work.
- Support: this includes the encouragement, sponsorship and resources provided by the organisation, line management and colleagues.
- **Relationships:** this includes promoting positive working to avoid conflict and dealing with unacceptable behaviour.
- **Role:** whether people understand their role within the organisation and whether the organisation ensures that they do not have conflicting roles.
- **Change:** how organisational change (large or small) is managed and communicated in the organisation.

The Management Standards represent a set of conditions that, if present, reflect a high level of health well-being and organisational performance.

In addition, the standards:

- Demonstrate good practice through a step by step risk assessment approach.
- Allow assessment of the current situation using surveys and other techniques.
- Promote active discussion and working in partnership with workers to help decide on practical improvements that can be made.
- Help simplify risk assessment for work related stress by:
    - Identifying the main risk factors for work related stress.
    - Helping employers focus on the underlying causes and their prevention.

- Providing a yardstick by which organisations can gauge their performance in tackling the key causes of stress

Well-being

The relationship between well-being and mental health

The World Health Organisation (WHO) relates well-being and mental health as follows:

"Mental health is not just the absence of mental disorder. It is defined as a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community."

There is a two way relationship between well-being and health in that health influences well-being and well-being itself influences health.

WHO goes on to say that “well-being comprises an individual’s experience of their life as well as a comparison of life circumstances with social norms and values”.

Examples of life circumstances include health, education, work, social relationships, built and natural environments, security, and work-life balance.

How health and well-being workplace strategy can help to improve workers’ health (mental and physical)

Many companies are starting to realise the benefits of Health and wellbeing. The creation of a health and wellbeing strategy not only demonstrates care for a worker’s health but also can be beneficial to the business.

By developing a health and wellbeing strategy, rather than just a collection of benefits, it ensures that workers health sits side by side with the company’s wider business objectives.

For example, if the business were looking to reduce absenteeism through sickness by 25%, it could ensure that the benefits focus on helping workers stay healthy or return to work quicker if they have been struck down by an illness.

By linking the strategy to the company’s objectives, it also enables the business to set KPIs, showing how the strategy can improve these areas. This in turn could help achieve senior management buy-in.

Having a strong health and wellbeing strategy will help workers avoid health issues, provide greater support, and return to work quicker if they do become ill. Some examples of this include encouraging exercise during the working day and the promotion of healthy eating initiatives. Health assessments can also help identify potential health risks and the provision of a Worker Assistance programme.

In addition, engaged workers are good for business. When workers are engaged at work an organisation can often see improvements in employee wellbeing and performance, productivity, and reductions in absence and staff turnover.

As more and more companies invest in a clearly defined health and wellbeing strategy it highlights that worker wellbeing is no longer a ‘nice to have’ but an area of importance to both employers and workers. Workers will appreciate their employers helping them to improve their health and employers will benefit from lower levels of absence and increased productivity.

The link between health and well-being and safety culture

Health and Wellbeing must start with an employer genuinely caring about their workers. It's important that wellbeing isn't simply confined to initiatives around maintaining or promoting physical health (although these are simple, visible, and beneficial schemes). Instead, organisations should consider whether there are fundamental issues about how work is managed which may be promoting or undermining employee wellbeing.

Therefore, the safety culture of an organisation can have an impact on wellbeing. The HSE's stress management standards can be a good starting point in this aspect but other aspects of health and wellbeing that link back to the safety culture include lower accident rates and a great awareness and control of workplace risks.

Whilst the stress management standards are a good starting point, discussions with staff may reveal more innovative solutions. Workers can have greater involvement in or control over the organisation of their work and workplace.

Why line managers must be trained on well-being strategies and initiatives

Line managers, given their position within an organisation, are often best placed to spot the signs of poor mental health in the workplace and if they are equipped with the right skill set can manage issues effectively before they reach a crisis point.

The actions and behaviour of the Line Manager can also have an impact on worker wellbeing: a good line manager will foster the kind of working environment that makes workers feel valued, respected and supported, and will act as a 'gatekeeper' protecting them from any working conditions that present risks to their mental wellbeing. However a bad line manager can aggravate and, in some cases, even be the cause of stress, anxiety and depression.

Taking into account that businesses have both a legal and moral duty to ensure the health and safety of their workers, training line managers to deal with mental health issues should be a top priority. Line managers can be a key asset in creating healthier, happier and more productive workforces and helping their employers comply with the law, providing they are equipped with the relevant skills.

Work-related violence

Meaning

Violence can be defined as a form of unwanted behaviour or action in the relations between two or more people. It is characterised by aggressiveness which is sometimes repeated and sometimes unexpected.

It includes incidents where employees are abused, threatened, assaulted or subject to other offensive acts or behaviours in circumstances related to their work.

Violence manifests itself both in the form of physical and psychological violence. It ranges from physical attacks to verbal insults, bullying, mobbing, and harassment, including sexual and racial harassment.

Violence may be internal (takes place between workers) or external (takes place between workers and other persons present in the workplace, for example visitors, members of the public)

The relationship between physical and psychological violence

Physical violence		Psychological violence
Physical attacks		bullying
beating	harassment	mobbing
kicking	sexual harassment	abuse
slapping	racial harassment	threats
stabbing	assualt	starring
shooting		
pushing		
biting		

What is Harassment?

Harassment is a form of unwanted behaviour. It occurs when someone is repeatedly and deliberately abused, threatened and/or humiliated in circumstances relating to work. It can happen on its own or alongside other forms of discrimination.

Unwanted behaviour might include:

- spoken or written words or abuse
- offensive emails, tweets, or comments on social networking sites
- images and graffiti
- physical gestures

The physical and psychological effects

Psychological consequences can be even more serious than physical wounds. The individual consequences of workplace harassment vary from minor stress reactions to long-term sick leave and displacement from working life and may sometimes even be a cause of suicide.

Physical and psychological violence are related. Any violent act or behaviour that affects physical well-being also affects psychological well-being and vice versa.

Psychological symptoms can include:

- Anxiety
- Depression
- Post-Traumatic Stress Syndrome
- Deterioration of relationships

These can lead to various physiological symptoms:

- Increase in blood pressure through stress
- Insomnia
- Loss or increase in appetite
- Increase in use of alcohol, drugs, or tobacco, as a coping strategy
- Stress-related stomach ulcers

Factors likely to Increase the Risk of Work-Related Violence

Certain work factors, processes, and interactions can put people at increased risk from workplace violence. These include:

- Working with the Public
- The Caring and Teaching Profession
- Social Services and Social Workers
- Working with people with mental ill-health conditions, or alcohol/drug impaired people.
- Working Alone
- Home-Visiting
- Handling Money and Valuables
- Carrying out Inspection or Enforcement Duties
- Retail and Licenced trade

Working with the Public

Working with the public puts workers at risk of external physical or verbal violence, which is by far the most common type of violence. There are many different types of occupation which work with the public, and some of these situations present additional risks (such as handling valuables).

Call centre agents can also experience verbal violence, particularly if they make outbound sales calls. The sales calls are usually unwelcome, and this can result in regular episodes of verbal abuse. The constant stress of this is what leads to the high turnover rate in call centres. Inbound call centres are not exempt from this. Often, customers call a call centre because they have a problem or a complaint. If the call centre agent is unable to resolve this, the customer's dissatisfaction can lead to verbal abuse.

The Caring and Teaching Profession

Carers can be affected by violence from the people they are caring for, especially if the person has some kind of learning disability and tends to physically thrash out when angry.

Teachers are at risk of being assaulted by students. Older students may be armed. There have been numerous cases of teachers being stabbed or murdered. But even young children have significant strength and can hit a teacher during a dispute.

Teachers are also perceived to have authority, which adds to the risk.

Social Services and Social Workers

Social Workers can be affected from violence by the nature of the client group they are dealing with. They may be dealing with vulnerable children in unpredictable home environments, or having to deal with clients who have mental, physical or learning disabilities. They can also suffer threats for example if they have to remove children from a home. They are also at risk as tend to work around the clock and are more vulnerable to working alone in the community.

Working with people with mental ill-health conditions or alcohol/drug impaired people

Healthcare professionals, especially those working in emergency services, are at risk of experiencing violence. Weekends tend to be very busy in accident and emergency wards.

Late-night drinkers and partygoers have accidents (or are injured whilst fighting) and attend the hospital still under the influence of alcohol or other drugs. Their decision making is flawed, and their behaviour not rational, leading to a risk of attacking the health care personnel. Furthermore, there can be a long wait for medical treatment, leading to growing anger.

Other occupations may have to work with alcohol or drug-impaired people, such as certain charity workers who support them, the police, and other government workers.

Those who work directly with psychiatric clients are also at risk of being attacked. Whilst many people with mental health problems are quite peaceful, some do have a tendency to be violent. Carers, nurses, and anyone who works in a psychiatric facility in contact with patients, are at risk.

Working Alone

People who work alone can be seen as an easy target since there is no immediate assistance to help them.

People who work at night often work alone. They may be alone and responsible for retail premises (such as a late-night shop) or work alone in a large facility (for example, an isolated part of a factory, empty storeroom) or work in public services.

Home-Visiting

Some workers may have to visit people in their homes. For example, for technical repairs, or client consultations. This increases the risk because the worker is entering an unfamiliar location.

Homes normally have only one or two exits, and there is a risk of the worker getting trapped inside if a violent home-owner stands between them and the exit.

Handling Money and Valuables

Any worker who handles valuables or drugs is at risk of being attacked. This affects people who handle money, such as cashiers, bank tellers, post office workers, etc. It can also affect other workers who carry valuable equipment or money. Workers in Financial and Accounts departments may be asked to collect large sums of money from a bank. Engineers may carry expensive tools and equipment in their vehicles. Sales people may use expensive mobile telephones and laptops, and drive expensive company vehicles, making them a target for robbery.

These risks can be increased further if other risk factors are involved, such as working late nights (fuel service stations and late night pharmacies), working alone (often late at night), or mobile workers (such as delivering money to cash machines and banks).

Carrying out Inspection or Enforcement Duties

Anyone who is perceived to be in a position of authority is potentially at risk of violence. When this authority figure uses their power against a member of the public, or against a professional, a common reaction is that of resistance. This resistance to authority can become violent.

Professions that exert authority include many types of government worker, such as police officers, traffic wardens, social service workers, doctors, the military, and decision makers. However, private sector workers can also be affected, such as private security officers, or managers making unpopular customer service-related decisions.

Retail and Licenced trade

All customer facing jobs have a potential risk of violence if customers are unhappy with the service being provided. For example, cashiers in the retail environment may become frustrated with lengthy queues, or when the checkout system experiences a technical problem or internet crash. The violence may range from verbal abuse to physical assault.

Those who sell alcohol will face people who are under the influence of alcohol. This can include bars and clubs. They often have a legal duty to refuse to serve people who are drunk, which inevitably leads to confrontations.

Other sources of alcohol include licensed shops, which often stay open late at night. Whilst most customers are perfectly respectable, small shops selling alcohol are often frequented by alcoholics, whose behaviour can be unpredictable.

Four stages for effectively managing work-related violence

The four stages, recommended by the UK HSE, are:

Stage 1: Finding out if you have a problem

Stage 2: Deciding what action to take

Stage 3: Take action

Stage 4: Check what you have done

It is important to remember that these four stages are not a one-off set of actions. If stage 4 shows there is still a problem then the process should be repeated.

The first two stages are completed by carrying out a risk assessment.

1. Finding out if you have a problem

The first step in risk assessment is to identify the hazard – in this case violence. Whilst an organisation may think that violence is not a problem in their workplace or that incidents are rare, workers' views may be very different.

Workers can be asked about their experiences of aggression and violence in short questionnaires. This can help identify groups of workers, situations, shifts, locations, activities, etc. which show an increased risk of violence. Accident and incident records can also assist with this.

It is good practice to share the results of the survey with the workforce so they realise that the situation is being taken seriously.

The company policy should include violence and aggression in its definition of "incident". This, accompanied with information and training, will help workers understand that these incidents should be reported like any other.

It is a good idea to record these incidents. You may find it useful to record the following information:

- An account of what happened.
- Details of the victim(s), the assailant(s), and any witnesses.
- The outcome, including working time, lost to both the individual(s) affected and to the organisation as a whole.
- The details of the location of the incident.

For a variety of reasons, some workers may be reluctant to report incidents of aggressive behaviour which make them feel threatened or worried. They may, for instance, feel that accepting abuse is part of the job. You will need a record of all incidents to enable you to build up a complete picture of the problem. Encourage workers to report incidents promptly and fully and let them know that this is what you expect.

You can use the details from your incident records along with the classifications to check for patterns. Look for common causes, areas, or times. The steps you take can then be targeted where they are needed most.

A survey by a UK trade union (USDAW) after 12 separate shop robberies found that each incident occurred between 5 and 7 o'clock in the evening. This finding could have useful security lessons for late night opening of stores and shops.

Try to predict what might happen - do not restrict your assessment to incidents which have already affected your own employees. There may be a known pattern of violence linked to certain work situations. Trade and professional organisations and trade unions may be able to provide useful information on this. Articles in the local, national, and technical press might also alert you to relevant incidents and potential problem areas or liaison with the local Police Force who may have Neighbourhood Teams and know of any local hotspots and areas of concern.

2. Deciding what action to take

Having found out that violence could be a problem for your employees you need to decide what needs to be done. Continue the risk assessment by taking the following steps to help you decide what action you need to take.

Identify which employees are at risk - those who have face-to-face contact with the public are normally the most vulnerable. Where appropriate, identify potentially violent people in advance so that the risks from them can be minimised.

Check existing arrangements, are the precautions already in place adequate or should more be done? Remember it is usually a combination of factors that give rise to violence. Factors which you can influence include:

Training and information: Train your employees so that they can spot the early signs of aggression and either avoid it or cope with it. Some organisations may make employees attend mandatory Conflict Resolution Training . It is important to make sure they fully understand any systems you have set up for their protection, for example some organisations make use of Lone Worker systems with GPS tracking which can provide alerts. Provide employees with any information they might need to identify clients with a history of violence or to anticipate factors which might make violence more likely. This can include things such as a computer system that can flag up red alerts on clients.

The environment: Provide better seating, decor, lighting in public waiting rooms and more regular information about delays. Consider physical security measures such as: video cameras or alarm systems; coded security locks on doors to keep the public out of staff areas; wider counters and raised floors on the staff side of the counter to give staff more protection. Consider inviting clients into buildings where they can be managed in a securer environment instead of employees going into homes. If working in homes, ensure employees are able to sit near an exit if needs be.

The design of the job: Use cheques, credit cards or tokens instead of cash to make robbery less attractive. Bank money more frequently and vary the route taken to reduce the risk of robbery.

Check the credentials of clients and the place and arrangements for any meetings away from the workplace.

Arrange for staff to be accompanied by a colleague if they must meet a suspected aggressor at their home or at a remote location or consider meeting in a secure environment.

Make arrangements for employees who work away from their base to keep in touch through the use of mobile phones or lone worker systems.

Maintain numbers of staff at the workplace to avoid a lone worker situation developing.

3. Take action

Your policy for dealing with violence may be written into your health and safety policy statement, so that all employees are aware of it. This will help your employees to co-operate with you, follow procedures properly and report any further incidents. Ensure that regular refresher training is undertaken for employees.

4. Check what you have done

Check on a regular basis how well your arrangements are working, consulting employees or their representatives as you do so. Consider setting up joint management and safety representative committees to do this.

Keep records of incidents and examine them regularly; they will show what progress you are making, any patterns of behaviour and if the problem is changing.

If your measures are working well, keep them up. If violence is still a problem, try something else. Go back to Stages 1 and 2 and identify other preventive measures that could work.

Lone working

What is a lone worker?

Lone workers are those who work by themselves without close or direct supervision (ref: UK HSE INDG 73). They are found in a wide range of situations; some examples are given below:

- People in fixed establishments where only one person works on the premises, e.g. in small workshops, kiosks, shops and home workers.
- People who work separately from others in factories, warehouses, research and training establishments, leisure centres or fairgrounds.
- People who work outside normal hours as cleaners, security, special production, night shift workers, maintenance and repair staff.
- People who work away from their home base on construction sites, in plant installation, maintenance, cleaning work, electrical repairs, lift work, painting and decorating or vehicle recovery.
- Agricultural and forestry workers.
- Service workers who collect rents, postal workers, home carers, community nursing staff, pest control workers, drivers, engineers, estate agents, sales representatives and similar professionals visiting domestic and commercial premises.

How general risk assessments can be used to avoid and control risks to lone workers

Whilst you may not be legally required to conduct a specific, separate risk assessment for lone workers, you should include risks to lone workers in any general risk assessment and take steps to avoid or control risks where necessary. This should include:

- Involving workers when considering potential risks and measures to control them;
- taking steps to ensure risks are removed where possible, or putting in place control measures, for example by carefully selecting work equipment to ensure the worker can perform what is required safely such as a lone worker device
- instruction, training and supervision;
- reviewing risk assessments periodically and updating them after any significant changes, such as new staff, processes or equipment;
- when the lone worker is working at another employer's workplace or in another environment, consulting with that employer to identify any risks and required control measures.

Risk assessment should help you decide on the right level of supervision for lone workers. There are some high-risk activities where at least one other person may need to be present. Examples include working:

- in a confined space, where a supervisor may need to be present, along with someone dedicated to the rescue role
- near exposed live electricity conductors
- in diving operations
- Working with vulnerable members of the public

The impact on risk to lone workers of specific hazards:

Many of the hazard encountered by a lone worker are to a large extent no different than those affecting groups of workers - in other words, the hazards associated with the tasks that they are undertaking.

However, lone workers may face greater risks in certain cases. For example:

- The threat of violence (particularly if working in "public" places - for example a kiosk operator in a 24-hour garage).
- The nature of the work may pose greater risks for lone workers (for example work in confined spaces; diving work; handling explosives, working with vulnerable members of the public).
- When carrying out manual handling activities that may require assistance.
- Chemicals and hazardous substances being used that may pose a risk to the worker.
- If machinery is involved in the work that one person cannot operate safely.
- Where the lone worker has a pre-existing medical condition.
- Where the lone worker's first language is not English, communications may be compromised, especially in an emergency.

What if a lone worker is working from home?

Employers have the same responsibility (moral, if not legal) for the safety and health of employees who work from home, as for any other employees. This means providing supervision, education and training, as well as implementing enough control measures to protect the homeworker.

For example, setting up a workstation and providing sufficient equipment to allow a homeworker to carry out the task without risks to health and safety.

Problems facing lone workers

Medical conditions:

Employers should seek medical advice if necessary. Consider both routine work and foreseeable emergencies that may impose additional physical and mental burdens on an individual. Examples here could include those employees who may have to manage Diabetes or suffer from Epilepsy.

Training:

Training is particularly important where there is limited supervision to control, guide and help in uncertain situations.

Training may also be crucial in enabling people to cope with unexpected circumstances and with potential exposure to violence and aggression.

Lone workers are unable to ask more experienced colleagues for help, so extra training may be appropriate. They need to be sufficiently experienced and fully understand the risks and precautions involved in their work and the location that they work in.

Employers should set the limits to what can and cannot be done while working alone. They should ensure workers are competent to deal with the requirements of the job and are able to recognise when to seek advice from elsewhere.

Supervision:

The extent of supervision required depends on the risks involved and the ability of the lone worker to identify and handle health and safety issues.

The level of supervision needed is a management decision, which should be based on the findings of a risk assessment, i.e. the higher the risk, the greater the level of supervision required. It should not be left to individuals to decide whether they need assistance.

Where a worker is new to a job, undergoing training, doing a job that presents specific risks, or dealing with new situations, it may be advisable for them to be accompanied when they first take up the post.

Emergencies:

The employer's assessment of the risks should identify foreseeable events. Emergency procedures should be established and employees trained in them.

Information regarding emergency procedures should be given to lone workers. The risk assessment may indicate that mobile workers should carry first-aid kits and/or that lone workers need first-aid training or access to a lone working device. They should also have access to adequate first-aid facilities.

Mental health issues

Arising from being isolated for long periods from the rest of the workforce.

Precautions for lone workers

Safe working procedures must be in place for lone workers. They should be issued only when it has been confirmed that the lone worker can adequately control the risks associated with the task.

Communication will be an essential part of these procedures. This may include:

- Supervisors periodically visiting and checking on people working alone.
- Pre-agreed intervals of regular contact between the lone worker and supervisor
- Using phones, radios, or email, bearing in mind the worker's understanding of English.
- Manually operated or automatic warning devices which trigger if specific signals are not received periodically from the lone worker such as a Lone Worker Device.

Procedures should be robust enough to ensure a lone worker has returned to their base or home once their task is completed. Other considerations:

- Does the lone worker have a safe way in and out of the workplace?
- Can one person handle temporary access equipment, plant, goods, or substances?
- Is there a risk of violence?
- Are women especially at risk?
- Do young people work alone?

9.3: Health Surveillance

The distinction between general health assessment and health surveillance

There are several types of health assessment that might be carried out in a workplace.

Fitness for Work: The primary purpose of health assessment fitness for work is to make sure that an individual is fit to perform the tasks involved effectively and without risk to their own or others' health and safety. It is not the intention to exclude a person from a job but to make any necessary reasonable modifications or adjustments to the job to allow the person to work efficiently and safely. An assessment may be required when:

- The individual's health condition may limit or prevent them from performing the job effectively (e.g. musculoskeletal conditions that limit ability).
- The individual's condition may be made worse by the job.
- The individual's condition may make certain jobs and work environments unsafe to them personally (e.g. liability to sudden unconsciousness in a hazardous situation, risk of damage to the remaining eye in an individual with monocular vision).
- The individual's condition may make it unsafe both for themselves and for others in some roles.

Employment health assessment: In some countries (such as the UK with the Equality Act 2010) it is illegal for prospective employers to ask questions or issue health questionnaires as part of the recruitment process. Employers are still permitted to make job offers conditional on satisfactory health checks. Therefore, employers may still ask health-related questions and require workers to undergo medical checks once a job has been offered. This health assessment may lead to the organisation making reasonable adjustments to the person's work or workplace.

Return to work assessment. A well-managed early return to work will reduce the risk of the absence becoming long-term. In general, people find it more difficult to return to work after a long-term absence. Encouraging a speedy

return to work is linked with a number of activities that are recognised as good practice in terms of early return to work. These actions include:

- Keeping in regular contact with the worker
- Reviewing the situation
- Return to work discussions
- Staged return

Health Surveillance

Health surveillance is a way of monitoring any possible ill-health effects that could be related to work exposures. For example, hearing tests for those exposed to noise at work, hand arm vibration checks for those working with vibration emitting tools, or surveillance for workers involved in asbestos or lead removal activities. Health surveillance is NOT a substitute for good control measures. It is a process that supports and hopefully confirms that control measures are effective.

In some countries, health surveillance is legally required when working with certain hazardous materials. For example, in the UK asbestos and lead workers are required to undergo periodic health surveillance checks.

The elements of the UK HSE's health surveillance cycle

The HSE recommend that the health surveillance cycle has seven steps. The diagram below provides an overview of those steps. As can be seen in the diagram, the employer has a central role in every aspect with involvement from workers to ensure effective implementation.

The UK HSE's Health Surveillance Cycle

Step 1: Risk Assessment and Controls

The starting point is your risk assessment. Through this, you will have found out the hazards in your workplace, identified who is at risk and take measures to do something to control the risks. Where some risk remains and there is likely to be harm caused to your workers, you will need to take further steps. Consider health surveillance if your workers are at risk from:

- Noise or vibration.
- Solvents, dusts, fumes, biological agents, and other substances hazardous to health.
- Asbestos, lead, or work in compressed air.
- Ionising radiation.

Control measures may not always be reliable, despite appropriate checking and maintenance. So, health surveillance can help make sure that any ill-health effects are detected as early as possible.

Step 2: Do I Need Health Surveillance?

If there is still a risk to health after the implementation of all reasonable precautions, you may need to put a health surveillance programme in place. This should also be supplemented by a robust Health Surveillance policy. Health surveillance is required if all the following criteria are met:

- There is an identifiable disease or adverse health effect and evidence of a link with workplace exposure.
- It is likely the disease or health effect may occur.
- There are valid techniques for detecting early signs of the disease or health effect.
- These techniques do not pose a risk to workers.

Step 3: What Sort of Health Surveillance?

Where your risk assessment shows that you need to implement health surveillance, you will need to put into place a programme that adequately addresses the risks and potential ill-health effects your workers may be exposed to.

In its simplest form, health surveillance could involve workers checking themselves for signs or symptoms of ill-health following a training session on what to look for and who to report symptoms to. For example, workers noticing soreness, redness, and itching on their hands and arms which are signs of Dermatitis and likely to be caused where they work with substances that can irritate or damage the skin.

A variation on this method of health surveillance is providing workers with annual questionnaires, asking them about their health and whether they have noticed any suspicious symptoms or health effects. Not only does this raise an awareness of the health effects to look for, but it is also a slightly more formal process, providing a written record of the surveillance which can be used for defending prosecutions or compensation claims.

A responsible person can be trained to make routine basic checks, such as skin inspections or signs of rashes and could be a supervisor, worker representative, or first aider. For more complicated assessments, an occupational health nurse or an occupational health doctor can ask about symptoms or carry out periodic examinations.

Examples of health surveillance include:

- Skin checks
- Lung function tests (also called spirometry)
- Eyesight tests
- Audiometry

Step 4: Setting Up a Health Surveillance Programme

Where health surveillance is required, the employer has a central role in every stage of health surveillance.

When setting up health surveillance arrangements, it is important to involve your workers and their representatives at an early stage as it is only effective with their cooperation. Your workers should also understand:

- Their own legal and contractual duties, (in terms of attending appointments, and participating constructively in the health surveillance process).
- The purpose of the health surveillance.

Step 5: Identify Who Will Do the Health Surveillance

As an employer, you are responsible for putting in place the most appropriate health surveillance programme for your business.

To put an effective programme in place you will need to:

- Involve your workers.
- Appoint a responsible person within your business.
- Appoint a competent medical professional (where appropriate).

After designing your programme, you may need to appoint an occupational health provider to deliver it and help you meet your legal obligations. However, by understanding a little more about what they do, you can be an 'intelligent customer' and purchase the right health surveillance services.

Step 6: Implement the Programme for those who Need it

The next step is to implement your health surveillance programme for those workers who need it. Keep your health surveillance programme under review, to make sure that it remains appropriate and to maintain quality.

This means carrying out activities, such as:

- Giving workers information about the health surveillance, and what is expected of them.
- Training the workers in self-checks and examinations.
- Training managers in the importance of health surveillance, so they are more likely to release workers for appointments.
- Create any relevant questionnaires to be used.
- Set up an appointment schedule, which meets the requirements, but which is also realistic in terms of releasing people from their daily activities. It is common to have a small number of people checked every week throughout the year.
- Create arrangements for record-keeping and regular review of the results.

Step 7: Manage Performance and Act on Results

Once your health surveillance arrangements are up and running, and you start receiving feedback from your service provider or responsible person, you need to act on the results. It is often useful to appoint someone to make sure any findings are promptly fed back to management, who can use this information to review the risk assessment and controls.

Once you have the results, you should:

- Act to protect those who are found to have health issues and organise further assessment. Consider the options for dealing with workers found with ill-health who may no longer be fit to be exposed, or those

who have restrictions placed on exposure. This may require a referral to see the Occupational Health provider.
- Act on results where potential workplace problems are found.
- Keep health surveillance records in line with regulatory requirements

Noise health surveillance

The requirements for health surveillance related to noise can be found in **the ILO Code of Practice: Ambient Factors in the Workplace** (9.4), which states:

Appropriate health surveillance should be conducted for all workers whose noise exposures reach a certain level prescribed by national laws and regulations or by national or internationally recognized standards above which health surveillance should be carried out; this may include:

(a) a pre-employment or pre-assignment medical examination to:

- determine any contraindication to exposure to noise
- detect any sensitivity to noise
- establish a baseline record useful for later medical surveillance

(b) periodical medical examinations at intervals prescribed as a function of the magnitude of the exposure hazards to:

- detect the first symptoms of an occupational disease
- detect the appearance of any unusual sensitivity to noise and signs of stress due to noisy working conditions

(c) medical examinations prior to resumption of work after a period of extended sickness or in case of conditions as may be specified in national legislation or internationally recognised standards

(d) medical examinations performed on cessation of employment to provide a general picture of the eventual effects of exposure to noise

(e) supplementary and special medical examinations when an abnormality is found, and it requires further investigation.

The results of the medical examinations and of supplementary examinations and tests, such as audiometric testing, of everyone should be recorded in a confidential medical file. The worker should be informed of these results and their significance accordingly.

Health surveillance for hearing damage usually means:

- Regular hearing checks in controlled conditions.
- Telling workers about the results of their hearing checks.
- Keeping health records.
- Ensuring workers are examined by a doctor where hearing damage is identified.

We use the term ‘audiometry’ or ‘audiometric testing’ when referring to hearing tests.

Circumstances where Audiometry may be Required

Audiometry should be provided:

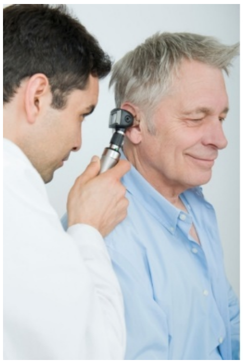
- If noise levels in the workplace are such that national legislation requires audiometry to be carried out.
- Or if there is a risk of hearing loss from work-related noise exposure.

In the UK, employers are legally required to carry out audiometric testing on any worker who is likely to exceed a daily personal exposure more than 85dB(A).

Ideally, audiometry should be started before people are exposed to noise (i.e. for new starters or those changing jobs), to give a baseline record of their hearing before exposure begins. That way, future results of audiometry can be compared to their initial test to identify any significant change.

Audiometry can, however, be introduced at any time for workers already exposed to noise. This would be followed by a regular series of checks, usually annually for the first two years of employment and then at three-yearly intervals (although this may need to be more frequent if any problem with hearing is detected or where the risk of hearing damage is high). Additionally, health surveillance may be carried out following complaints or concerns from workers or their representatives.

The hearing checks need to be carried out by someone who has the appropriate training. The whole health surveillance programme needs to be under the control of an occupational health professional (for example a doctor or a nurse with appropriate training and experience).



An example of a hearing check being carried out

The Purpose of Audiometric Health Surveillance

The purpose of audiometric health surveillance is to:

- Warn employers when workers might be suffering from early signs of hearing damage.
- Give employers an opportunity to do something to prevent the damage getting worse.
- Check that control measures are working. Consult worker representatives and the workers concerned before introducing health surveillance. It is important that workers understand that the aim of health surveillance is to protect their hearing.

The Method of Audiometric Testing

An audiometer hearing test is typically given to a person in a soundproof booth wearing headphones connected to the audiometer. The audiometer produces tones at specific frequencies (typically between 250Hz and 8 kHz) and calibrated volume levels to each ear in sequence. The test administrator notes the loudness, in decibels, on an audiogram.

People having their hearing tested signal that they have heard the tone either raising a hand or pressing a button. The goal is to identify the hearing threshold, or softest tone a person can hear, at each sound frequency. The test administrator notes the results on an audiogram template. The frequency is on the x-axis and the loudness on the y-axis. Finally, the points are joined by a line to convey which frequencies are not being heard normally and what degree of hearing loss may be present.

The audiometric testing is accompanied by a questionnaire to identify the subject's professional and personal background and any previous or non-work-related exposures to noise. For example, the subject will be asked about their previous work history and any previous exposure to noise (such as working in a factory or serving in the military), along with any personal hobbies which may be noisy (such as playing a musical instrument or shooting rifles). The questionnaire will also ask about the individual's habits in relation to noise at work, such as whether they wear their hearing protection correctly or not.

The information collected on the questionnaire may explain any existing hearing damage. It can also help defend any civil claims, since the organisation may be able to show that the hearing damage occurred prior to employment, or that the individual knowingly failed to wear their PPE.

The audiometric testing is also a great opportunity to reinforce the importance of protecting hearing, explaining why hearing protection and PPE is necessary, and demonstrate how to wear it correctly.

Interpretation of Audiometric Results

The amount (or degree) of hearing loss a person experiences is based on hearing sensitivity. To determine a person's degree of hearing loss, their hearing thresholds must be determined. Hearing thresholds are defined as the lowest level sound that can be heard 50% of the time. The decibel (or dB) is the unit of intensity used to describe hearing sensitivity. During a diagnostic hearing evaluation, the threshold is measured at different frequencies (or Hertz, Hz) in each ear.

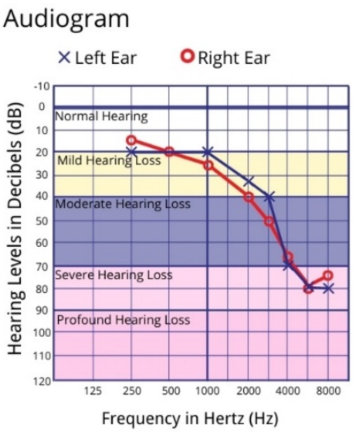
The degree of hearing loss is expressed by the difference between a person's threshold and the average threshold for people with normal sensitivity (0-20dB). For example, persons with mild hearing loss have thresholds that are 25 to 40 dB higher than the thresholds for those with normal hearing. The list below outlines different hearing loss thresholds as they are determined in relation to an individual with a normal hearing threshold.

- Mild hearing loss: 25 to 40 dB higher than normal.
- Moderate hearing loss: 40 to 55 dB higher than normal.
- Moderate-to-severe hearing loss: 55 to 70 dB higher than normal.
- Severe hearing loss: 70 to 90 dB higher than normal.

•	Profound loss: 90 dB or more.

The graph below represents a blank audiogram and illustrates the degrees of hearing loss listed above. Frequency is plotted at the top of the graph, ranging from low frequencies (250 Hz) on the left to high frequencies (8000 Hz) on the right. Sound level, in dB, is plotted on the left side of the graph and ranges from very faint sounds (-10 dB) at the top to very intense sounds (120 dB) at the bottom.

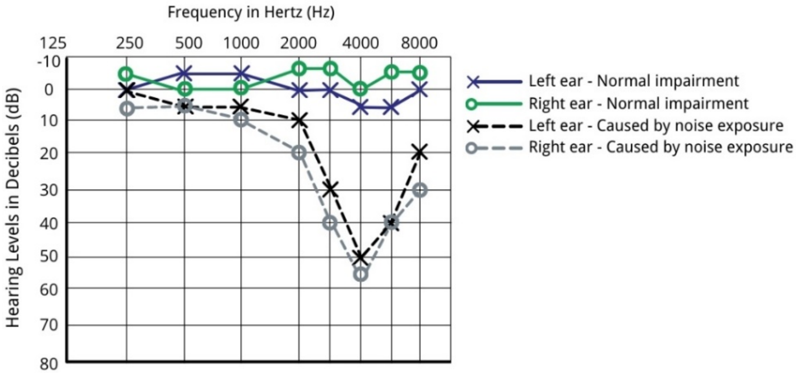
Understanding the information shown on an audiogram is relatively straightforward. Let's look at an example. In the audiogram below, hearing thresholds for the right ear are represented by red circles. Thresholds for the left ear are represented by the blue X. In the right ear, this person has normal hearing in the lower pitches indicated by a red circle corresponding to 15 dB at 250 Hz and 20 dB at 500 Hz. Hearing thresholds in the high pitches fall into the severe degree of hearing loss, as the threshold at 2000 Hz is 40 dB, 65 dB at 4000 Hz, and 75 dB at 8000 Hz. Can you determine the degree of hearing loss for the left ear?



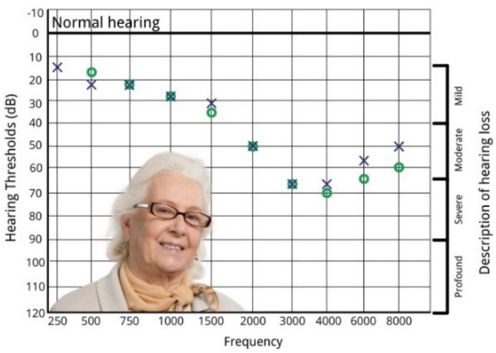
Hearing is normal in the lower frequencies (250, 500 and 1000Hz) but deteriorates in the higher frequencies, with a mild loss of 35dB at 2000 Hz, a mild to moderate loss at 3000Hz, moderate to severe loss of 70dB at 4000 Hz and a severe loss of 80 dB at 8000 Hz.

The following audiogram shows an example of normal hearing (solid lines) and noise induced hearing loss caused by noise exposure (dotted lines). Note the characteristic dip at around the 4000 Hz frequency, indicating exposure to noise.

Example of an audiogram showing a typical dip around 4kHz, indicative of noise-related hearing loss.



The audiogram below is indicative of a condition known as presbycusis. This results from degeneration of the hair receptors within the cochlea due to the ageing process. It usually affects the higher frequencies more than the low.



Advantages and Limitations of Audiometry Programmes

Advantages

- May help to demonstrate legal compliance, since a lack of measurable hearing loss shows the risks to hearing are well managed. Furthermore, audiometric testing may be required by law in certain countries.
- Pre-employment testing gives a basis against which future tests can be compared.
- Can assist in defence of civil claims since the pre-employment testing may show that hearing loss had already occurred before starting work.
- May result in lower insurance premiums since the insurer will be reassured that noise risks are being managed.
- May assist in identifying control measure deficiencies. If workers suffer hearing damage, then this should be investigated like any other accident or instance of ill-health.

Limitations

- Increased costs to the organisation. Audiometric testing requires a soundproof booth, a room to install it in, an audiometer, staff to carry out the testing, admin to organise the tests and appointments, and releasing workers from their normal duties to be tested.

- Can be inaccurate if the subject is uncooperative since it relies on the subject signalling that they can hear the sounds.
- It is reactive in that it determines loss of hearing that has already occurred. It does not help prevent injury.
- The subject may feel claustrophobic in a sound booth.
- Finally, and significantly, an audiometric testing programme may increase civil claims. Since the workers will become aware that their hearing has been damaged, they may be inclined to then pursue the organisation for compensation.

Vibration health surveillance

The ILO publication, ambient factors in the workplace, recommends the following:

- A pre-employment medical examination should examine candidates for jobs affected by hand-arm vibration for Raynaud's phenomenon of non-occupational origin and for hand-arm vibration syndrome (HAVS) from previous employment. Where these symptoms are diagnosed, such employment should not be offered unless vibration has been satisfactorily controlled.
- If a worker is exposed to hand-transmitted vibration, the occupational health professional responsible for health surveillance should:
    - examine the worker periodically, as prescribed by national laws and regulations, for HAVS and ask the worker about symptoms
    - examine the worker for symptoms of possible neurological effects of vibration, such as numbness and elevated sensory thresholds for temperature, pain, and other factors.
- If it appears that these symptoms exist and may be related to vibration exposure, the employers should be advised that control may be insufficient. The employer should review the assessment and in particular control the causative vibration.
- Because of possible association of back disorders with whole-body vibration, workers exposed should be counselled during health surveillance about the importance of posture in seated jobs, and about correct lifting technique.

Keeping Health and medical records confidential

Health records

A health record must be kept for all employees under health surveillance.

Records are important because they allow links to be made between exposure and any health effects. The ILO Code of practice "Safety in the use of chemicals at work" recommends that, where there are no recognised national laws or practice, surveillance records should be kept for a period of 30 years.

Individual, up-to-date health records must be kept for each employee placed under health surveillance. These should include details about the employee and the health surveillance procedures relating to them.

The record should be kept in a format that it can be linked with other information (e.g., with any workplace exposure measurements).

If you are collecting an historical record of jobs or tasks completed during current employment, involving exposure to identified substances requiring health surveillance it is useful to store them with this record.

Sharing of information

It is good practice to offer individual employees a copy of their health record when they leave your employment. If your company changes hands, consider offering the health record to the individual employee, and/or to the new occupational health service provider. Make sure that health records are stored securely.

Confidentiality

Health records are different to medical records in that they should not contain confidential medical information. Health records and medical records must therefore be kept separate to avoid any breaches of medical confidentiality.

Any personal medical information should be kept in confidence and held by the occupational health professional responsible for the health surveillance programme.

Medical records

Medical records are compiled by a doctor or nurse and may contain information obtained from the individual during health surveillance. This information may include clinical notes, biological results and other information related to health issues not associated with work. This information is confidential and should not be disclosed without the consent of the individual.

The occupational health (OH) professional may obtain data as the result of an immunisation programme (for example, blood titres or 'non responder' information). This information will be provided to the employee and should not be given to the employer. It will be kept in confidence by the OH professional and should only be made known to the employer with the employee's consent.

The doctor or nurse should only provide employers with information on fitness to work and any restrictions that may apply in that respect. Employees can have access to their own medical record through a written request. (Data protection issues may have to be considered). These details can only be released to third parties, such as the employer, on receipt of the informed written consent of the employee, or possibly by a court order.

Biological Monitoring

Biological monitoring involves analysis of breath, urine, or blood samples collected from workers. There are sensitive ethical issues involved in the collection, analysis, and reporting of results from such samples. Occupational physicians play a crucial role in handling such sensitive issues.

It is strongly recommended that you involve an occupational physician in setting up a biological monitoring programme, particularly in establishing procedures for reporting results. They should be available to offer a medical interpretation of results.

However, they may not need to be involved in the day-to-day sample collection and analysis.

In addition to specifying the requirements for medical and health surveillance, section 4 of the ILO Code of Practice "Occupational exposure to substances harmful to health" also specifies requirements for biological monitoring. Section 4.3 states:

"4.3.1(1) Whenever valid biological monitoring methods are available, they should be used to complement monitoring of the working environment in order to increase protection of workers' health.

4.3.1(2) Under certain circumstances, such as work in the open, biological monitoring may be the most practical method in view of the difficulty of monitoring the working environment.

4.3.2. Biological monitoring complements monitoring of the working environment by assessing the absorption of harmful substances both in the individual and in the group, and by evaluating individual susceptibility…"

Section 4.4 goes on to state:

" 4.4.1. (1) Evaluation of the overall hazard presented by the working environment should be based on the results from the group of workers exposed to a given level of the harmful substance, in order to offset the effect of individual biological variability.

(2) Any worker for whom the findings exceed the biological limits should undergo further and repeated biological and medical investigations."

The role of biological limits

Biological monitoring can be a very useful complementary technique to air monitoring when air sampling techniques alone may not give a reliable indication of exposure. Biological monitoring is the measurement and assessment of hazardous substances or their metabolites in tissues, secretions, excreta or expired air, or any combination of these, in exposed workers. Measurements reflect absorption of a substance by all routes.

Biological monitoring may be particularly useful in circumstances where there is likely to be significant skin absorption and/or gastrointestinal tract uptake following ingestion; where control of exposure depends on respiratory protective equipment; where there is a reasonably well-defined relationship between biological monitoring and effect; or where it gives information on accumulated dose and target organ body burden which is related to toxicity.

Advantages and Disadvantages of biological limits when compared to Airborne Monitoring

Advantages include:

- All exposure routes are considered (inhalation, absorption, ingestion, injection). All circumstances are considered (including multiple and uneven exposures).
- It considers individual response (variability in absorption, metabolism, excretion).

Disadvantages include:

- Are usually unable to specify the source of the exposure (occupational or non-occupational).
- May not be sufficiently specific to a particular chemical.
- Are not suitable for identification of workplace contaminations in general.
- May be interfered by other chemicals in the biological medium (e.g. medications).
- Are not useful at all for the assessment or monitoring of acute and/or local toxic effects (e.g. irritation).
- And the provision of samples for bio monitoring may be a burden for workers (e.g. blood samples).
- Biological monitoring can be intrusive e.g. blood tests or urine samples.
- Strict procedures are necessary to prevent cross contamination of samples.
- Some laboratory testing can be expensive. The occupational health personnel necessary to carry out certain tests can also be expensive.
- It can be difficult to organise the presence of occupational health personnel to carry out testing on a night-shift due to the unsociable hours.
- Where biological monitoring is not legally required, the employer will need to obtain the written consent of workers. They cannot force the workers to provide samples. This can be a significant challenge when introducing a new biological monitoring programme.

Why health assessments should be offered to shift/night workers

Managing shift workers

There is no specific, universal definition of shift work. It can be considered to be:

"a work activity scheduled outside standard daytime hours, where there may be a handover of duty from one individual or work group to another, and/or a pattern of work where one employee replaces another on the same job within a 24-hour period".

Research has shown that there can be undesirable consequences for those working shifts outside standard daytime hours, particularly those covering the night or with early morning starts.

For example, shift work may result in:

- disruption of the internal body clock
- Fatigue
- sleeping difficulties
- disturbed appetite and digestion
- reliance on sedatives and/or stimulants
- social and domestic problems

which in turn can affect performance, increase the likelihood of errors and accidents at work and might have a negative effect on health. The risk of errors, accidents and injuries has been found:

- to be higher on the night shift
- to rise with increasing shift length over eight hours
- to increase over successive shifts, especially if they are night shifts
- to increase when there are not enough breaks

Fatigue, night work and/or shift-working arrangements have been cited as major contributory factors in numerous well-documented accidents and incidents including Three Mile Island in 1979, Bhopal in 1984, Challenger Space Shuttle in 1986, Chernobyl in 1986, Clapham Junction in 1988 and Exxon Valdez in 1989.

Health effects

- As well as chronic fatigue, there is some evidence associating long-term exposure to shift work and the following ill health effects.
- gastrointestinal problems such as indigestion, abdominal pain, constipation, chronic gastritis, and peptic ulcers.
- cardiovascular problems such as hypertension, coronary heart disease.
- increased susceptibility to minor illnesses such as colds, flu, and gastroenteritis.

Best practice guidelines for shift work

The UK HSE publication HSG 256 offers this best advice currently available regarding shift work schedule design and the workplace environment. These are best practice guidelines and should include the following points:

- Plan a workload that is appropriate to the length and timing of the shift.
- If reasonably practicable, schedule a variety of tasks to be completed during the shift and allow workers some choice about the order they need to be done in.

- Avoid scheduling demanding, dangerous, monotonous and/or safety-critical work during the night, early morning, towards the end of long shifts and during other periods of low alertness.
- Avoid placing workers on permanent night shifts.
- If possible, offer workers a choice between permanent and rotating shift schedules.
- Where possible, adopt a forward-rotating schedule for rotating shifts rather than a backward-rotating schedule.
- Either rotate shifts very quickly, e.g. every 2-3 days or slowly, e.g. every 3-4 weeks and avoid weekly/fortnightly rotating shift schedules.
- If not strictly necessary for business needs, try to avoid early morning starts before 7.00 am.
- Where possible, arrange shift start/end times to be convenient for public transport or consider providing transport for workers on particular shifts.
- Limit shifts to a maximum of 12 hours (including overtime) and consider the needs of vulnerable workers.
- Limit night shift or shifts where work is demanding, monotonous, dangerous and/or safety critical to 8 hours.
- Consider if shifts of a variable length or flexible start/end times could offer a suitable compromise.
- Avoid split shifts unless necessary to meet business needs.
- Encourage and promote the benefit of regular breaks away from the workstation.
- Where possible, allow workers some discretion over when they take a break, but discourage workers from saving up break time in order to leave earlier.
- In general, limit consecutive working days to a maximum of 5-7 days and make sure there is adequate rest time between successive shifts.
- Where shifts are long (> 8 hours), for night shifts and for shifts with early morning starts, it may be better to set a limit of 2-3 consecutive shifts.
- When switching from day to night shifts or vice versa, allow workers a minimum of 2 nights' full sleep.
- Build regular free weekends into the shift schedule.
- Provide similar facilities and opportunities for shift workers as those available for your daytime workers.
- Ensure that workplace lighting is adequate and adjustable by workers.
- Ensure that the workplace temperature is adjustable and allows workers to carry out their tasks in reasonable comfort.
- Consider increasing supervision during key periods of low alertness, eg during the night, early morning, towards the end of long shifts and other periods of low alertness.
- Make sure supervisors and team members with responsibility for shift-working arrangements are aware of the risks associated with shift work and can recognise shift work-related problems.
- Control overtime and shift swapping by monitoring and recording hours worked and rest periods.
- Discourage workers from taking second jobs.
- Make provision in the work schedule to allow adequate rest for those workers carrying out standby/on-call duties or overtime.
- Provide training and information for workers, their families and management on the risks associated with shift work and on coping strategies. This may help workers to cope better with shift work.
- Make provision to release staff for foreseeable training, development, and communication needs.
- Encourage interaction between workers and provide a means of communication for lone workers.
- Agree on, and ensure timing and procedures for transmitting information to the next shift team are followed at all times.
- Encourage workers to inform their doctor about their working arrangements.

- Promote healthy living strategies such as increasing exercise and improving diet.
- Ensure that free health assessments are provided for night workers.
- Ensure that the workplace and its surroundings are well lit, safe, and secure and that workers are free from the threat of violence.

What is fatigue?

Fatigue refers to the issues that arise from excessive working time or poorly designed shift patterns.

It is generally considered to be a decline in mental and/or physical performance that results from prolonged exertion, sleep loss and/or disruption of the internal clock. It is also related to workload, in that workers are more easily fatigued if their work is machine-paced, complex or monotonous.

Fatigue results in slower reactions, reduced ability to process information, memory lapses, absent-mindedness, decreased awareness, lack of attention, underestimation of risk, reduced coordination etc.

Fatigue can lead to errors and accidents, ill-health and injury, and reduced productivity. It is often a root cause of major accidents e.g. Herald of Free Enterprise, Chernobyl, Texas City, Clapham Junction, Challenger and Exxon Valdez.

Managing fatigue

The UK HSE specific topic guidance 2 on “Managing fatigue risks” highlights an approach to managing fatigue.

Essentially, fatigue needs to be managed, like any other hazard. During incident investigations, for example, evidence on possible fatigue should be sought.

Changes to working hours need to be risk assessed. One way of doing this is to use the UK HSE’s Fatigue and Risk Index Calculator Version 2.2. This tool has been developed as a simple tool to enable comparison of differing shift patterns and to identify when fatigue risks are excessive.

Employers may need to set limits for working hours and shift patterns and these need to be monitored and enforced.

It should be remembered that operators may prefer badly designed shift patterns for social reasons, such as ones which give long breaks between shifts despite having to work 14-hour shifts.

Good practice guidance on shift roster design includes:

- Restrict number of night shifts (to 4 maximum if possible).
- Move early shift starts before 6am forward (e.g. 7am not 6am start).
- If 12-hour shifts worked then no overtime worked in addition.
- Avoid long working hours (more than 50 hours per week).
- Allow minimum of 12 hours between shifts and avoid ‘quick return’ of 8 hours if possible. (Rest period between shifts should permit sufficient time for commuting, meals and sleep.)
- Rotate shifts quickly (e.g. every 2-3 days). Avoid rotating shifts every 1-2 weeks.
- Use forward rotation (morning/afternoon/night) for preference.

- Arrange start/finish times of the shift to be convenient for public transport, social and domestic activities

Deciding when health surveillance may be appropriate

The starting point is the risk assessment process. If, after implementing control measures, some risk remains further steps might need to be taken. This may involve implementing health surveillance programmes. It may also be beneficial to develop a Health Surveillance Policy.

In some countries, legislation may lay down health surveillance requirements. For example, workers exposed to high levels of noise, asbestos, lead, or ionising radiation are required to have health surveillance programmes in place.

Health surveillance would generally be required if:

- there is an identifiable disease/adverse health effect and evidence of a link with workplace exposure.
- it is likely the disease/health effect may occur.
- there are valid techniques for detecting early signs of the disease/health effect.
- these techniques do not pose a risk to employees.

In its simplest form, health surveillance could involve employees checking themselves for signs or symptoms of ill health following a training session on what to look for and who to report symptoms to. For example, employees noticing soreness, redness and itching on their hands and arms, where they work with substances that can irritate or damage the skin.

A responsible person can be trained to make routine basic checks, such as skin inspections or signs of rashes and could, for example, be a supervisor, employee representative or first aider. For more complicated assessments, an occupational health nurse or an occupational health doctor can ask about symptoms or carry out periodic examinations.

Examples of situations where health surveillance might be appropriate include:

- workers with known mental ill-health conditions
- workers who will be working at height
- driving occupations (such as forklift truck or long-distance lorry drivers)
- checking for alcohol/substance abuse at work

How to establish and maintain an alcohol/drugs policy

All organisations can benefit from an agreed policy on drug/alcohol misuse. You could include a drug and alcohol policy as part of your overall health and safety policy.

If an employee tells you, they have a drug or alcohol problem, an effective policy should aim to help and support them rather than lead to dismissal.

But it should also highlight when you will take disciplinary or other action, for example that you will report drug possession or dealing at work to the police straight away.

Before introducing a drugs/alcohol policy organisations should consult with workers. Consultation involves you not only giving information to employees but also listening to them and taking account of what they say.

You could ask your employees what they know about the effects of drugs and alcohol on health and safety and the restrictions or rules on drug and alcohol use in your business.

The benefits of pre-employment health screening for alcohol/drugs.

There may be a case for pre-employment screening, particularly in certain jobs (for example workers who make safety-critical decisions like train drivers, pilots, and chemical process operators). In jobs like these the misuse of drugs or alcohol could have disastrous effects for the worker, colleagues, members of the public and the environment.

By screening pre-employment and ensuring that potential applicants are made aware of the screening policy, organisations can reduce the number of candidates who apply with a pre-existing drug or alcohol problem.

When testing for alcohol/drugs should be carried out

Before embarking on testing, organisations should ensure that the benefits justify any adverse impact, unless there is a legal requirement for testing.

Information collected from testing is more likely to be justified and accepted if it can be demonstrated it is for reasons of health and safety. For example, workers carrying out safety critical tasks in high-risk industries where mistakes, as a result of the influence of drugs/alcohol, could have catastrophic consequences.

Many organisations operate "with cause" testing regimes. This means that if there is reasonable suspicion that a worker is under the influence as a result of their behaviour or performance, they will be required to be tested for suspected alcohol or drug misuse. Anyone refusing to take a test may be subject to disciplinary action.

The disadvantages of alcohol/drugs testing

Research has suggested that organisations that seek to excessively test their workers are unlikely to create a work environment that encourages trust, loyalty, and commitment. Workers who are under excessive testing regimes are more likely to have a negative attitude towards work and are more likely to suffer from stress related issues.

9.4: Hazardous substances

The structure and function of human anatomical systems:

To understand the impact of hazardous substances on the human body, we will need to study some basics about human anatomy.

In the following pages we will be covering the:

- Respiratory system
- Digestive system
- Circulatory system
- Nervous system
- Skin
- Eyes
- Nose and sense of smell

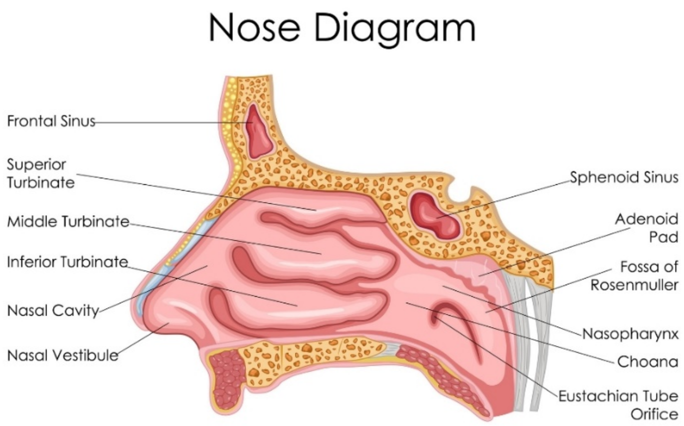
The Respiratory System

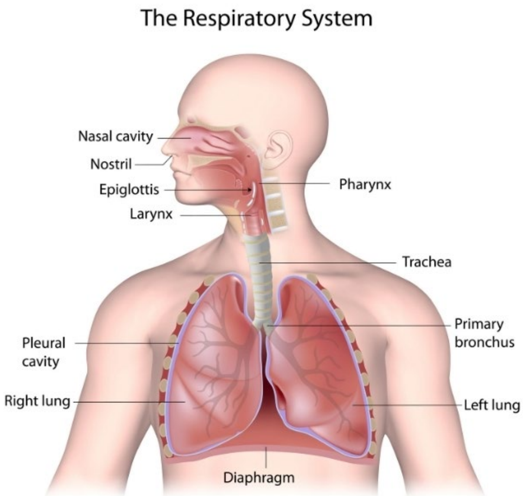
Respiration is where air is inhaled through the nostrils and nasal cavities, or the mouth.

The air enters the trachea and proceeds down through the right and left bronchi which branch out into bronchioles.

Each of the bronchioles terminates in a cluster of alveoli, where the gas exchange takes place.

Oxygen is absorbed into the bloodstream, and carbon dioxide is emitted. Upon exhalation, the air is pushed back upwards towards the nostrils and mouth carrying with it the CO2.





Respiratory System

The average person who is moderately active during the daytime breathes about 20,000 litres of air every 24 hours. Inevitably, this air contains potentially harmful particles and gases. Particles, such as dust and soot, mould, fungi, bacteria, and viruses deposit on airway and alveolar surfaces.

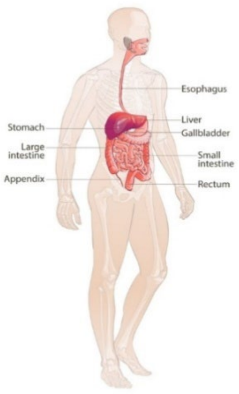
There are approximately 150 million alveoli in each adult lung. This provides a surface area of 160m2 which is the size of a tennis court. This large surface area makes the lungs incredibly efficient at carrying substances into the bloodstream.

Digestive System

The digestive system is formed of the digestive tract. This is a series of organs from the mouth, oesophagus, stomach, small intestine, large intestine, rectum, and anus. Inside these organs is a mucous membrane. In the mouth, stomach, and small intestine, the mucous membrane contains tiny glands which produce juices that help digest food.

Digestion starts in the mouth when chewing. Enzymes in the saliva start the digestion of starches to sugars. Absorption is then completed in the small intestines.

The digestive tract also contains a layer of muscle to help break down food and move it along the tract. The liver and pancreas produce digestive juices that enter the intestine.



DIGESTIVE SYSTEM

Circulatory System

The circulatory system is comprised of the heart, the circulatory vessels (veins, arteries, capillaries, etc.), and blood.

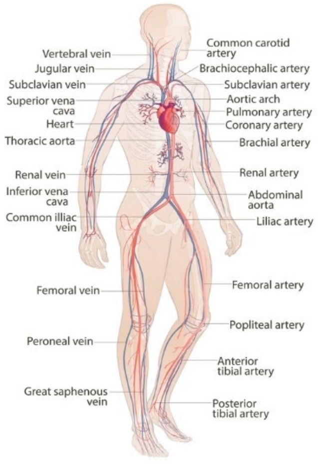
The circulatory system supplies nutrients and oxygen to the body and removes any by-products, such as toxins and CO2.

The heart is a muscle that acts as a pump to move blood throughout the body. As the heart beats, the right side of the heart receives blood that is depleted of oxygen and sends it to the lungs for oxygenation. The left side of the heart pumps this newly oxygenated blood from the lungs and sends it around the body.

The two main vessels of the circulatory system are arteries and veins. There are also supporting vessels called capillaries. Arteries carry oxygen rich blood to all the muscles and tissues that need it. The arteries have special walls that can respond to hormones and other chemicals that are released by the body. These hormones cause the walls of the arteries to expand or contract to control the pressure and flow of the blood as it goes through the system. Branching off from these large arteries are smaller blood vessels called capillaries.

Once the oxygen and nutrients have been absorbed from the blood by the tissues, the blood is returned to another type of major vessel called a vein. The veins return oxygen depleted blood back to the heart and onto the lungs.

Blood consists of two types of blood cells: red and white. The red blood cells contain haemoglobin, which absorbs oxygen and carries it to the tissues of the body. The white cells are a part of the immune system and fight infection.



CIRCULATORY SYSTEM

Nervous System

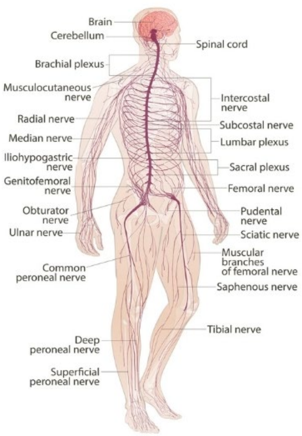
The nervous system is divided into two main systems:

- The central nervous system (CNS)
- The peripheral nervous system (PNS)

The spinal cord and the brain make up the CNS. The function of the CNS is to obtain information from the body and send out instructions. The PNS is composed of nerves. The brain sends and receives messages to the body through the spinal cord and nerves.

The nerve system is made up of neurons. The messages move from one neuron to another. Nerve signals must jump across a tiny gap between neurons. The nervous system can act at an incredible speed, sending messages across the body almost instantly.

Neurons, unlike other body tissues, have limited ability to repair themselves. Nerve cells cannot be repaired if damaged.



NERVOUS SYSTEM

The Skin

The skin is the largest organ of the human body. It is supple which allows it to move. But it is strong enough to give some resistance to breaking or tearing. Its texture and thickness vary across the body. For example, the skin of the lips and eyelids is very thin and delicate, but the skin on the heels of the feet is thicker and harder.

The skin serves several purposes:

- Waterproof cover for the body
- Defence against bacteria and other organisms
- A cooling system, thanks to sweat glands
- A sensory organ that provides information on pain, pleasure, temperature, and pressure

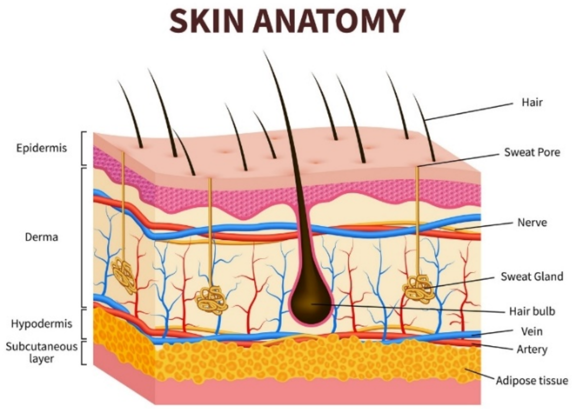
The external layer of the skin is known as the epidermis. This protects the inner layers which are more delicate. The epidermis consists of several layers of cells. The bottom layer is where new epidermal cells are formed. As old cells are lost from the surface fresh ones will replace them.

The epidermis also contains melanin. This is the pigment which gives our skin its colour. It also causes the skin to darken to protect itself from sunlight and ultraviolet radiation.

Underneath the epidermis is the dermis. It contains the sweat glands, hair follicles, blood vessels, and nerves.

When the temperature is hot, perspiration comes out of the sweat glands and evaporates on the skin, taking the heat with it. If the temperature is cold, the blood vessels in the dermis contract. This helps to reduce heat loss. Glands in the dermis secrete a substance called sebum to lubricate the skin.

Both the dermis and epidermis have nerve endings. These transmit sensations to the brain. The fingertips have more nerve endings than other parts of the body.



The Eyes

The eyeball is contained in a bony socket which points towards the back of the head. The eyeball sits inside the socket and is surrounded by a layer of fat to cushion it and allow movement.

The eyeball is encased in a white structure called the sclera. This is a durable material that protects the eyeball from damage. The cornea is the transparent part of the sclera that covers the iris which is the coloured part of the eye.

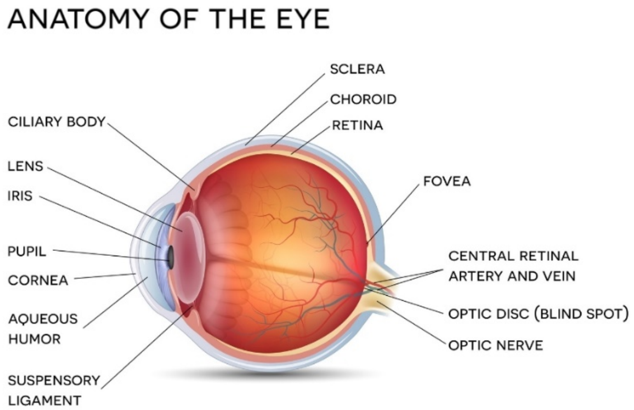
Light enters the pupil, a hole in the middle of the eye. The iris is a series of muscles that permit it to adjust the size of the pupil's opening to regulate the amount of light that enters the eye.

When there is not sufficient light, the iris adjusts the pupil's opening to receive the maximum amount. When there is too much light or the light is too bright, the iris contracts or dilates the pupil's opening so that it takes in enough light to function.

The light passes through the pupil and enters the eye through the lens. The purpose of the lens is to focus the light on the back of the eyeball.

After leaving the lens, the light passes through a gel like substance called a vitreous humour which helps the eye to retain its shape. It then hits the retina, which is a light sensitive tissue, where chemical and electrical impulses are created. These travel to the brain along the optic nerve, where they are understood as pictures.

The conjunctiva is a thin delicate mucus membrane that covers the front of the eyeball and lines the inside of the eyelids. The eyeball is covered by the eyelid, which helps to prevent scratches, entry of dust, and assists in the lubrication of the surface. There are several tear glands around the eyelids. Each gland has a number of tear ducts. On blinking, the tears drain away via a small opening in the inner corner of the eyelid.



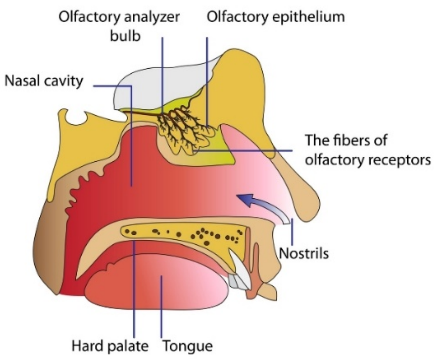
Nose and our Sense of Smell (Olfactory System).

All around us, things like coffee or diesel emit tiny molecules that can enter our olfactory system in two ways: either through our nostrils or the back of the throat (mostly everything emits molecules, from perfume to bread). We're mainly familiar with smelling through our nostrils, although eating food which releases molecules into the back of the throat can also cause us to smell.

Once inside your nostrils, these air molecules land on the olfactory epithelium — a tissue covered in mucus that lines the nasal cavity. The epithelium contains millions of olfactory receptors or neurons that are capable of binding with specific odour molecules. An odour molecule from a cup of coffee floating up into your nose will find and bind to an olfactory receptor that's specifically designed to identify that molecule.

Once the olfactory receptors bind with a specific odour, they send their electrical impulses to the brain which interprets the signal as a smell.

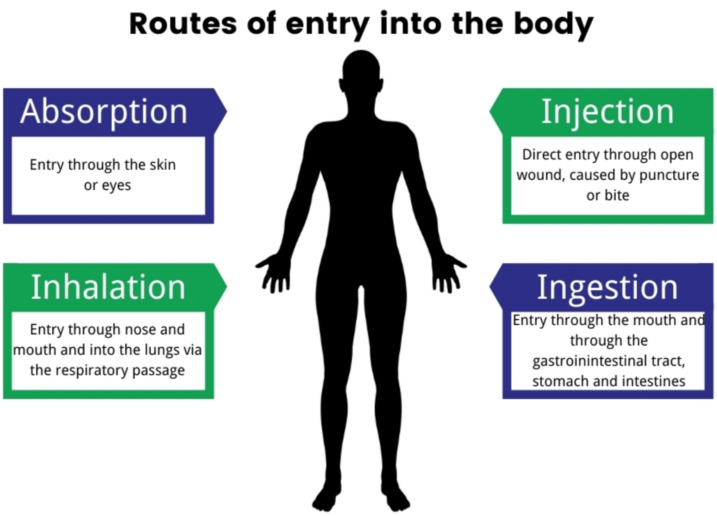
The Olfactory System



Main Routes of Entry into the Body

Hazardous substances can enter the body in a variety of ways, depending on the type of exposure and the form of the substance.

- Absorption through the skin, or through mucous membranes such as around the eyes
- Injection. This is direct entry through an open wound, or through a puncture or bite
- Inhalation through the nose and mouth and into the lungs via the respiratory passage
- Ingestion through the mouth and into the gastrointestinal tract, stomach, and intestines



Inhalation

Inhalation is the most common route of entry as many industrial toxic substances are in an airborne form. 90% of industrial poisons are absorbed through the lungs.

The size of particles that may enter the lungs is important. They are measured in microns. A micron is one millionth of a metre. The larger particles inhaled (greater than 10 microns) tend to only travel as far as the nose. Smaller particles may get past the nose and enter the bronchi and bronchioles (between 5 and 10 microns). Even smaller particles (less than 5 microns) are capable of reaching the deep lung i.e. the alveoli. The smallest particles (less than 0.3 microns) are usually exhaled without settling in the lungs.

Therefore the size of the particle may affect different parts of the respiratory system. For example, certain types of wood dust can cause nasal cancer, but lead fumes can penetrate deep into the lung and enter the bloodstream through the alveoli.

Skin Absorption

Substances can be absorbed through the intact skin. Skin is a semi-permeable membrane. It is normally waterproof, but some substances can pass directly through the skin and enter the bloodstream and be carried around the body to the target organs. Substances can also enter through cuts in the skin and through the thin membranes of the eye, ear, or nose. The amount absorbed through the skin adds to the dose that has entered through other routes, such as inhalation.

Many solvents can have a local effect on the skin such as defatting of the skin's essential oils. This can result in skin dryness, irritation, and with prolonged use cracking and irritant contact dermatitis.

Entry through the Eyes

Some substances are water soluble. This means that they dissolve in water. The mucous membranes of the eye are humid. Any water soluble substances that can come into contact with the eye can dissolve. In some cases, this means the substances can directly enter the bloodstream through the thin mucous membrane. In other cases this can cause irritation, corrosion, or destruction of the surrounding eye tissue.

Injection

The outer layer of the skin will normally keep out most substances. However, if something sharp pushes through the external layer and into the bloodstream, a hazardous substance could be carried with it and then carried around the body. Needles are the most obvious injection hazard, especially as they often contain blood and possible blood-borne pathogens. Other injection hazards can include broken glass, sharp metal, splinters, nails, staples, and anything else which has the capability of pushing through the skin and carrying contaminants into the body.

Ingestion

Ingestion is not a common route and predominantly occurs through poor hygiene practices as a consequence of workers eating or smoking with contaminated hands. This route of entry may become significant in work processes involved with toxic substances such as lead in assay laboratories.

Ingestion takes place through actions such as eating, drinking, smoking, a person touching their mouth, or licking their lips. Contaminants can enter the mouth where they can be absorbed through the thin membranes of the tongue and mouth, or can be swallowed and pass on to the stomach. Some absorption of chemicals can take place through the lining of the stomach very quickly. Once the substance enters the small intestine it can be absorbed into the blood capillaries. Just like the lungs, there is a large surface area inside the intestine where a substance can enter into the bloodstream. Once in the bloodstream the substance can travel around the body and affect the target organs.

The Concept of Target Organs and Target Systems

A target organ is a specific organ which is affected by a substance or agent.

Target organs can include the lungs, liver, kidneys, brain, skin, bladder, or eyes. Examples of substances and their target organs are:

- Asbestos, Silica and Coal dusts and isocyanates, which affect the lungs
- Nickel can cause nasal cancer
- Lead and mercury can affect the brain and nervous system
- Unrefined mineral oils can cause skin cancer
- Di-chromates, acids, alkalis can affect the skin
- Benzene which affects the bone marrow
- Beta naphthylamine can cause bladder cancer
- Alcohol and chlorinated solvents which can affect the liver
- Cadmium (heavy metal) can cause kidney disease

Some substances (such as lead and mercury) can affect more than one organ.

In addition to single organs, whole anatomical systems can be affected by substances. These are referred to as 'target systems'. These can include the nervous system, the circulatory system, and the reproductive system.

Examples of substances and their target systems include:

- Alcohol and solvents can slow down nervous system activity.
- Lead can interfere with the central and peripheral nervous systems, causing brain damage.
- Exposure to high levels of benzene can damage male fertility and damage unborn babies (reproductive system).

Local and Systemic Effects

Local effects are where a substance causes harm at the point of first contact with the body. For example, if the substance causes harm to the lungs when it is inhaled then you could say that it has a local effect on the lungs. Asbestos is a typical example of a substance that has a local effect.

If a substance enters the body via a route, such as by inhalation into the lungs, and then has a harmful effect on some other part of the body, then this would be a systemic effect. For example, carbon monoxide enters through the lungs, but replaces oxygen in the blood. This, in turn, starves cells of oxygen.

The body's defensive responses

Respiratory System

Large solid particles inhaled are initially filtered by nasal hairs. Particles that make it further inside the nose become caught by the small bones and the cartilage, causing deposition in the nose and its mucus lining. The fine hairs in the nose then pass these particles back to the outside when they can be blown out. Substances irritating the inside of the nose cause a reaction which results in the particles been expelled through the nose via sneezing.

Particles which penetrate further than the nose can reach the back of the throat where, if irritation occurs, results in expulsion via coughing. If particles reach the back of the throat without being expelled, they then enter the pharynx

and into the trachea. These airways contain a lining of sticky thick mucus which can dissolve some portions of substances or, along with the cilia (tiny hairs), can carry the mucus and particles upwards towards the back of the throat to be expelled. This is known as the mucociliary escalator.

If the particles continue forward into the respiratory system they will reach the bronchus and then the alveoli. If the particle is water soluble, then access to the alveoli might enable it to enter the bloodstream. Non-soluble particles can remain lodged where they will be attacked by the immune system. Cells called phagocytes will attack and try to consume the particles, removing their dead bodies via the lymphatic system.

Digestive System

Substances entering the body via the ingested route can be expelled almost immediately if there is an unpleasant taste. The particles are contained in the saliva in the mouth and can be spat out.

Progressing further through the digestive system unpleasant tastes can create a feeling of nausea in the body which can result in the toxic substances being expelled from the body via the process of vomiting.

Substances making the journey to the stomach can be dissolved in the stomach by the body's stomach acid.

If they can survive the stomach acid, toxic substances can then pass through the colon to be expelled as a waste product in stools or can be fast tracked through the system in an experience known as 'diarrhoea'.

The Skin

The skin is a marvellous mechanism which protects the body from toxic substances in a variety of ways. Initially the oily outer layer prevents substances from being absorbed. If this oily layer is breached, the external part of the epidermis (made up of dead cells) is sacrificed so that the underlying newer cells remain unharmed. Once this dead layer has been damaged the skin creates blisters (a protective bubble) to protect the layers underneath from further damage by keeping additional contaminants out.

If blood is drawn during the exposure (such as with corrosive substances), then the blood begins to clot, and a fibrous gel layer is created to prevent bacteria from spreading and prevents further contamination of the area.

Nervous System

The majority of the nervous system is protected by a blood-brain barrier, which is a layer of cells in blood vessel walls. This barrier will allow substances that serve a metabolic function to pass through but keeps damaging substances out. Compounds that are smaller or are fat-soluble can pass through this blood-brain barrier more easily. Those of a larger size or are water-soluble are kept out.

Circulatory System

The lymphatic system acts as a drainage system, removing foreign bodies and filtering out any infections before they can enter the blood system. The circulatory system allows cells to travel throughout the body to fight foreign objects and diseases. Macrophages (a type of white blood cell) attack invading particles and remove them from the body. Antimicrobial proteins enhance the bodies innate defences by attacking micro-organisms directly or preventing them from reproducing to halt or slow down any attack on the body.

Innate Immune System Response

The innate immune response provides immediate defence against infection. It comprises the cells and mechanisms that defend the body from infection by other organisms in a generic way. The defence mechanism is not tailored to the invading organism and it does not provide any protective immunity in the future.

Examples of innate immune response include:

- The production of histamines during an allergic reaction.
- Antibodies and phagocytic cells which attack and remove foreign cells from the body.

Adaptive Immune System Response

The adaptive immune system response is comprised of cells (lymphocytes) that have the ability to recognise and remember specific pathogens and to mount stronger attacks each time the pathogen is encountered. Cells pass on their adaptive ability and history through modifications of their DNA.

The distinction between inhalable and respirable dust

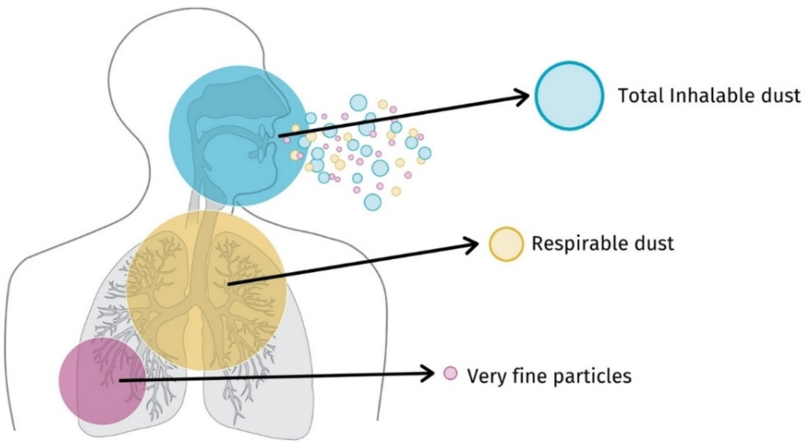
Total Inhalable Dust

Total inhalable dust is the fraction of airborne material which enters the nose and mouth during breathing and is therefore liable to deposition anywhere in the respiratory tract. The particle sizes of total inhalable dust are up to 100 microns.

Respirable Dust

Respirable dust is that fraction that penetrates to the deep lung where gas exchange takes place. The particle sizes of respirable dust are between 4 and 10 microns. Any smaller than that, the particles show random movement and waft in and out of the alveoli much like a gas.

These values are affected by respiration and hygroscopicity. The more water soluble the particle, the more likely it will dissolve higher in the airways before it reaches the deep lung.



9.5: Health risks from hazardous substances

The aims of "REACH"

REACH is a European Union regulation concerning the Registration, Evaluation, Authorisation, and Restriction of Chemicals. It came into force on 1st June 2007 and replaced several European Directives and Regulations with a single system.

REACH has several aims:

- To provide a high level of protection of human health and the environment from the use of chemicals.
- To make the people who place chemicals on the market (manufacturers and importers) responsible for understanding and managing the risks associated with their use.
- To allow the free movement of substances on the EU market.
- To enhance innovation in and the competitiveness of the EU chemicals industry.
- To promote the use of alternative methods for the assessment of the hazardous properties of substances e.g. quantitative structure-activity relationships (QSAR) and read across.

Registration

A major part of REACH is the requirement for manufacturers or importers of substances to register them with a central European Chemicals Agency (ECHA). A registration package is supported by a standard set of data on that substance. The amount of data required is proportionate to the amount of substance manufactured or supplied.

If the substances are not registered then the data on them will not be available and as a result, manufacturers or importers will no longer be able to manufacture or supply them legally, i.e. no data, no market!

Manufacturer Duties

Since 1 December 2008, chemical substances manufactured in Europe in amounts of 1 tonne or more per year have needed to be registered with the European Chemicals Agency (ECHA) in Helsinki. It is only chemicals on their own that are registered, not deliberate mixtures of chemicals (formulations/preparations). Where a chemical is supplied, or used as part of a deliberate mixture, it is the individual ingredients that are registered. In some cases, substances in articles need to be registered.

Manufacturers who want to continue to manufacture chemicals covered by REACH will need to register them with the European Chemicals Agency (ECHA) in Helsinki. Registration means providing a package of technical information on the chemical and its hazards. Registration is phased over a period of years based on tonnage levels and in some cases the hazards of the chemical. However, to take advantage of the phase in time chemicals need to be pre-registered.

Importers' Duties

Companies outside the EU cannot register chemicals themselves but can appoint an EU-based agent - an 'Only Representative' - to act on behalf their EU-based importers.

Companies wishing to continue to import chemicals covered by REACH you will need to register them with ECHA. Registration means providing a package of technical information on the chemical and its hazards. Registration is phased over a period of years based on tonnage levels and in some cases the hazards of the chemical. However, to take advantage of the phase in time chemicals need to be pre-registered.

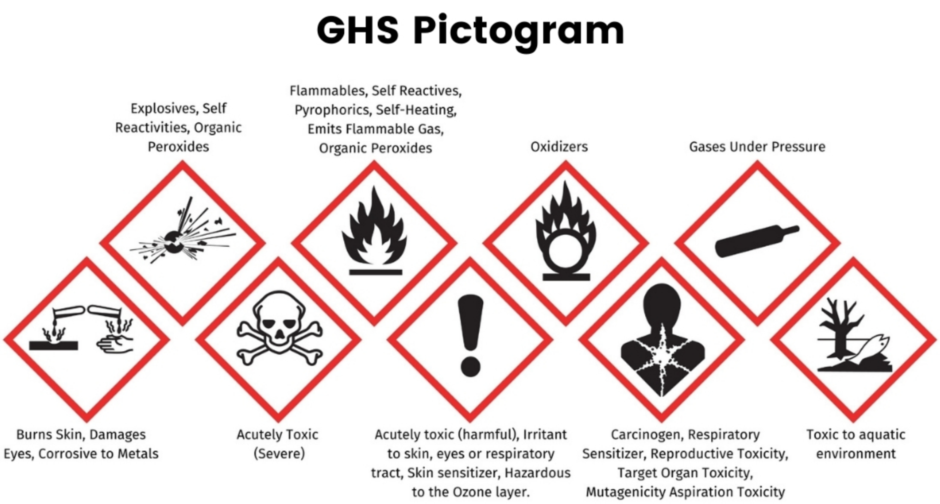
The Purpose of Classification and the Role of Hazard and Precautionary Statements

The Globally Harmonised System of Classification and Labelling of Chemicals (GHS) is an internationally agreed-upon system, created by the United Nations beginning in 1992. It was designed to replace the various classification and labelling standards used in different countries by using consistent criteria on a global level. The aim of the system is to create a common chemical labelling process globally.

European Regulation (EC) No. 1272/2008 on classification, labelling and packaging of substances and mixtures came into force on 20th January 2009 in all EU Member States, including the UK. It is known by its abbreviated form, 'the CLP Regulation' or just plain 'CLP'.

The CLP Regulation adopts the United Nations' Globally Harmonised System on the classification and labelling of chemicals (GHS) across all European Union countries, including the UK.

As GHS is a voluntary agreement rather than a law, it must be adopted through a suitable national or regional legal mechanism to ensure it becomes legally binding. That's what the CLP Regulation does.



GHS and CLP provides a logical approach to:

- Defining health, physical, and environmental hazards of chemicals.
- Creating classification processes that use available data on chemicals for comparison with the defined hazard criteria.
- Communicating hazard information, as well as protective measures, on labels and Safety Data Sheets (SDS).

Classification

The GHS classification system is a complex system, aiming to classify substances according to the severity of the hazard they pose. For example, a toxic substance could be classified into any one of five different toxicity classifications, depending on how toxic it is.

The hazardous classification process comprises three steps:

1. Identification of relevant data regarding the hazards of a substance or mixture.

2. Subsequent review of those data to ascertain the hazards associated with the substance or mixture and;
3. A decision on whether the substance or mixture will be classified as a hazardous substance or mixture and the degree of hazard, where appropriate, by comparison of the data with agreed hazard classification criteria.

Hazard Statements

Hazard statements form part of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS). They are intended to form a set of standardised phrases about the hazards of chemical substances and mixtures that can be translated into different languages. As such, they serve the same purpose as the well-known R-phrases, which they are intended to replace.

Hazard statements are one of the key elements for the labelling of containers under the GHS, along with:

- An identification of the product.
- One or more hazard pictograms (where necessary).
- A signal word - either Danger or Warning - where necessary.
- Precautionary statements, indicating how the product should be handled to minimise risks to the user (as well as to other people and the general environment).
- The identity of the supplier (who might be a manufacturer or importer).

Each hazard statement is designated a code, starting with the letter H and followed by three digits. Statements which correspond to related hazards are grouped together by code number, so the numbering is not consecutive. The code is used for reference purposes, for example, to help with translations, but it is the actual phrase which should appear on labels and safety data sheets. Example health hazard statements include:

- H300: Fatal if swallowed.
- H302: Harmful if swallowed.
- H310: Fatal in contact with skin.
- H312: Harmful in contact with skin.
- H314: Causes severe skin burns and eye damage.
- H315: Causes skin irritation.
- H317: May cause an allergic skin reaction.
- H318: Causes serious eye damage.
- H320: Causes eye irritation.
- H330: Fatal if inhaled.
- H332: Harmful if inhaled.
- H334: May cause allergy or asthma symptoms or breathing difficulties if inhaled.
- H335: May cause respiratory irritation.
- H340: May cause genetic defects.
- H350: May cause cancer.
- H360: May damage fertility or the unborn child.
- H370: Causes damage to organs.

Precautionary Statements

Precautionary statements form part of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS). They are intended to form a set of standardised phrases giving advice about the correct handling of chemical

substances and mixtures, which can be translated into different languages. As such, they serve the same purpose as the well-known S-phrases, which they are intended to replace.

Each precautionary statement is designated a code, starting with the letter P and followed by three digits. Statements which correspond to related hazards are grouped together by code number, so the numbering is not consecutive. The code is used for reference purposes, for example, to help with translations, but it is the actual phrase which should appear on labels and safety data sheets. Some precautionary phrases are combinations, indicated by a plus sign "+". In several cases, there is a choice of wording, for example, "Avoid breathing dust/fume/gas/mist/vapours/spray": the supplier or regulatory agency should choose the appropriate wording for the product concerned.

Precautionary statements can either be general, preventative, response or storage related. Examples include:

- P351: Rinse cautiously with water for several minutes.
- P352: Wash with plenty of water.
- P262: Do not get in eyes, on the skin, or on clothing.
- P263: Avoid contact during pregnancy/while nursing.
- P264: Wash thoroughly after handling.
- P270: Do not eat, drink, or smoke when using this product.
- P271: Use only outdoors or in a well-ventilated area.

Health Hazard Classes

'Classification' of a chemical is a scientific assessment of whether it can cause harm. For example, whether it has the potential to cause cancer, explode, irritate the eyes, etc.

Chemicals are classified so that people using them, either in industry or as consumers, can understand any hazardous effects they could have on human health or the environment and to protect against that harm.

Classification is about identifying intrinsic hazards, not controlling risks. It's about getting the information needed for decisions about risk control to be made so that chemicals can be produced, transported, used, and disposed of safely.

Classification is fundamental to safe chemical management. It is vital that classification is based on accurate, robust, and adequate data and information.

The GHS - Hazard Classes and Categories

Hazard Class	Hazard Classes and Categories				
Acute Toxicity: • Oral • Dermal • Inhalation	1	2	3	4	
Skin corrosion / irritation	1A	1B	1C	2	
Serious eye damage / eye irritation	1	2A			
Respiratory or skin sensitisation	1				
Germ cell mutagenicity	1A	1B	2		
Carcinogenic	1A	1B	2		
Reproductive toxicity - fertility	1A	1B	2		
Specific target organ toxicity - single exposure	1	2	3		
Specific target organ toxicity - repeated exposure	1	2			
Aspiration Hazard	1				

Acute Toxicity

Refers to the adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours.

Skin Corrosion

Is the production of irreversible damage to the skin; namely visible necrosis through the epidermis and into the dermis, following the application of a test substance for up to 4 hours.

Corrosive reactions are typified by bleeding, ulcers, bloody scabs and, by the end of absorption at 14 days, by discolouration due to blanching of the skin, complete areas of alopecia, and scars.

Skin Irritation

A substance is a skin irritant when it produces reversible damage to the skin following its application of up to 4 hours.

Serious Eye Damage

Is the production of tissue damage in the eye, or serious physical decay of vision, which is not fully reversible within 21 days of application of the test substance.

Eye Irritation

Is the production of changes in the eye following the application of test substance to the anterior surface of the eye, which are fully reversible within 21 days of application.

Respiratory/Skin Sensitisation

A respiratory sensitiser is a substance that will lead to hypersensitivity of the airways following inhalation of the substance.

A skin sensitiser is a substance that will lead to an allergic response following skin contact.

Germ Cell Mutagenicity

A germ cell mutagen is a substance that may cause mutations in the germ cells of humans that can be transmitted to the progeny (offspring.) A mutation is defined as a permanent change in the amount or structure of the genetic material in a cell.

Carcinogenicit

A carcinogen is any substance or a mixture which induces cancer, or increases its incidence. This may be due to the ability to damage the genome or to the disruption of cellular metabolic processes.

Reproductive Toxicity

Reproductive toxicity is associated substances that will interfere in some way with normal reproduction; such substances are called reprotoxic. It includes adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in the offspring.

Specific Target Organ Toxicity

Classification identifies the chemical substance as being a specific target organ/systemic toxicant and, as such, it may present a potential for adverse health impact to people who are exposed to it.

The effects may be after a single exposure (such as hydrofluoric acid) or after repeated exposure (such as asbestos).

Aspiration Hazard

Aspiration hazard means the entry of liquid and solid substances directly through the oral or nasal cavity, or indirectly through vomiting into the trachea and lower respiratory system.

Information on Substances to be Communicated to Users

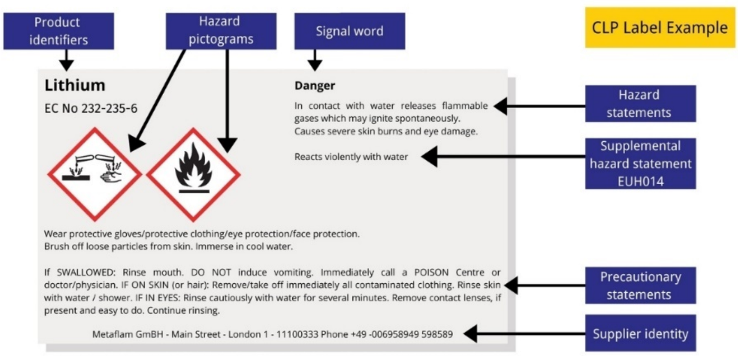
The CLP Regulation adopts the UN GHS system within the EU. The GHS aims to improve worker safety throughout the world by introducing a common set of hazard criteria and labelling elements to be used for chemicals. The GHS has some basic aims: ensure that chemical suppliers identify the hazards of their products, package them safely, and communicate information about the hazards through labels and other documents.

Labelling

CLP has not changed the purpose of the label, but the meaning of several of the symbols has changed, and CLP has made a number of changes to the details of the information to be provided, including:

- New red-framed pictograms to replace the familiar orange danger symbols.
- A signal word instead of indications of danger.
- Hazard statements instead of risk phrases.
- Precautionary statements instead of safety phrases.
- Some extra hazard statements now in a supplementary labelling section.

Other requirements, such as the requirement to show names and identifiers for hazardous substances or the hazardous component substances in a mixture, the name, address and telephone number of the supplier, and the nominal quantity of the package, are largely unchanged.



Safety Data Sheets

Safety Data Sheets are an essential component of the GHS and are intended to provide comprehensive information about a substance or mixture for use in workplace chemical management.

In the GHS, they serve the same function that the Material Safety Data Sheet or MSDS does in OSHA's "HazCom Standard" or in Europe and the United Kingdom under the REACH Regulations.

An SDS should be produced for substances and mixtures which meet the harmonised criteria for physical, health, or environmental hazards under the GHS. One is also needed for all mixtures which contain ingredients that meet the criteria for carcinogenic, toxic to reproduction, or specific target organ toxicity in concentrations exceeding the cut-off limits for SDS specified by the criteria for mixtures.

Competent authorities may also require SDSs for mixtures not meeting the criteria for classification but containing hazardous ingredients in certain concentrations.

Data Sheet Format

Information in the SDS should be presented using the following:

- Identification of the substance or mixture
- Hazard(s) identification
- Composition and information on ingredients
- First-aid measures
- Fire-fighting measures
- Accidental release measures (spillage and clean-up).
- Handling and Storage
- Exposure controls and personal protective equipment
- Physical and chemical properties
- Stability and reactivity
- Toxicological information
- Ecological information
- Disposal considerations
- Transport information
- Regulatory information
- Other information

SDS Content

An SDS should provide a clear description of the data used to identify the hazards. If specific information is not applicable or not available under a particular sub-heading, the SDS should clearly state this.

Some subheadings are national or regional in nature and SDSs should contain such information as is relevant for the area the SDSs are intended.

Chemical Safety Assessments and Reports

The chemical safety report documents the chemical safety assessment undertaken as part of the REACH registration process, and is the key source from which the registrant provides information to all users of chemicals through the exposure scenarios. It also forms a basis for other REACH processes including substance evaluation, authorisation, and restriction.

The chemical safety assessment is carried out to demonstrate that the risks from the exposure to a substance, during its manufacture and use, are controlled when specific operational conditions and risk management measures are

applied. These conditions of use of a substance constitute the exposure scenario, which is an essential component of the chemical safety report.

The chemical safety report should be readily understandable in all its parts as a stand-alone document and it should include all the relevant information for the chemical safety assessment. The principles applied in the hazard and exposure assessments, the assumptions made, and the conclusions drawn should be transparent and well documented.

Chemical Safety Assessment and Report Format

The Chemical Safety Report should include the following headings:

- Summary of risk management measures
- Declaration that risk management measures are implemented
- Declaration that risk management measures are communicated
- Identity of the substance and physical and chemical properties
- Manufacture and uses
- Classification and labelling
- Environmental fate properties
- Human health hazard assessment
    - Toxicokinetics (absorption, metabolism, distribution, and elimination)
    - Acute toxicity
    - Irritation
    - Skin
    - Eye
    - Respiratory tract
    - Corrosivity
    - Sensitisation
    - Skin
    - Respiratory system
    - Repeated dose toxicity
    - Mutagenicity
    - Carcinogenicity
    - Toxicity for reproduction
    - Effects on fertility
    - Developmental toxicity
- Exposure assessment
- Risk characterisation

What should be considered in the assessment of risks to health from hazardous substances?

Chemicals are used in virtually all work activities, thus presenting certain chemical risks in many workplaces all over the world. Many thousands of chemicals are used in substantial quantities, and many new chemicals are also introduced into the market each year. It is therefore an urgent task to establish a systematic approach to safety in the use of chemicals at work. An effective control of chemical risks at the workplace requires an efficient flow of information from the manufacturers or importers to the users of chemicals on potential hazards and on the safety precautions to be taken. This flow of information should be followed by daily action by employers to ensure that the necessary measures are taken to protect workers, and consequently the public and the environment.

The ILO Code of Practice “Ambient factors in the workplace” (Section 4.2) states:

“ As the first stage of the assessment, the employer should inspect the workplace and obtain information on:

(a) hazardous substances that are present or likely to occur.

(b) activities that take place.

(c) any hazardous substances or processes that may easily be eliminated”.

The ILO Code of practice for “Safe use of chemicals at work” goes on to state:

"6.2.1. The assessment should be carried out by employers or by persons acting on their behalf who have the necessary information, instruction and training and are competent to do so. It should include:

(a) Assessment of risks.

This should include consideration of which chemicals are used and the nature of their hazards, i.e. whether they may present a risk of one or more of the following:

- acute or chronic ill health by entry into the body through inhalation, skin absorption or ingestion;
- injury or ill health from skin or eye contact;
- injury from fire, explosion or other events resulting from physical properties or chemical reactivity;"

An assessment of the risks to health from hazardous substances will consider:

- The hazardous properties of the substances.
- The likely route of entry into the body.
- The effects of mixtures.
- The quantity in use and levels of exposure.
- The operating conditions and processes used.
- The range of uses of the chemical
- The number of people exposed
- The type and duration of the exposure
- The frequency of the exposure
- The variety and nature of the tasks, and the methods used
- The point at which the exposure becomes harmful (the "threshold of exposure")
- The consequences and likelihood of failure of existing control measures
- The results from relevant health surveillance and exposure monitoring
- Individual susceptibilities

Risk Assessment Review

The assessment should be reviewed annually or whenever there has been a significant change. This does not mean that the whole assessment process must be repeated at each review. The first purpose of review is to see if the existing assessment is still suitable and sufficient. If it is, then you do not need to do any more.

Factors to consider to help decide whether a review is required include:

Changes in the volume of production

For example, a circuit board factory uses a solder bath process. To date, local exhaust ventilation has successfully extracted fumes. Fulfilling a long-term order will mean working two eight-hour shifts instead of one. The ventilation equipment therefore must work twice as long and new staff will have to be employed. Assessment review would probably indicate revised maintenance schedules for the ventilation equipment and would have to address the information, instruction, and training needs of new personnel.

Changes in plant

For example, a park maintenance department uses several sprayers for small-scale application of pesticides. To reduce the quantity of chemicals purchased it is decided to use ultra low volume, hand-held sprayers instead. Much smaller amounts of chemical are needed and this is likely to be an overriding benefit with regard to reducing the risk. However, the chemicals are used in more concentrated forms and there is some potential for increased spray drift. This also needs to be considered.

Using different materials

For example, a car valeting specialist arranges with a commercial vehicle dealer to clean the cabs of lorries. The way he uses substances is much the same as for cars, but more heavy-duty cleaning materials are required. The assessment will need to consider the new substances involved.

Changes in process

For example, a toy factory paints components using a production line which passes through a paint bath. To improve finish quality and reduce paint wastage a spraying assembly replaces it. There is an obvious increase in the amount of vapour generated which requires assessment.

Are new control methods available? For example, a quarry installs a new rock-crushing plant. One of the benefits of this is that it is designed to limit the generation and spread of dust. At first sight this appears to reduce the need for an existing reliance on respirators, but the new equipment is subject to heavy wear and tear. Assessment will need to consider the maintenance needs of the new plant to sustain its dust suppression capabilities and to what extent respirators can be dispensed with, considering realistic levels of exposure.

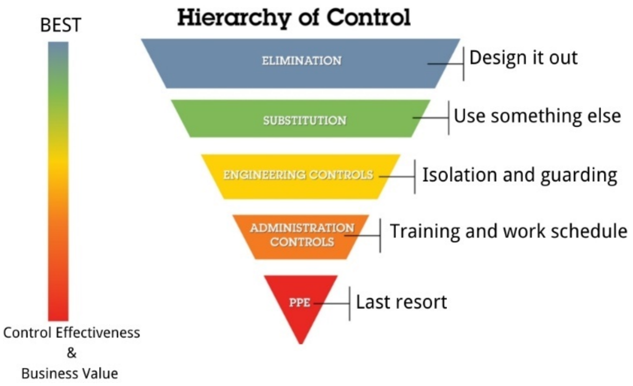
A review may also be required if:

- Ill-health related to work is reported.
- There is new evidence about hazards of substances.
- Monitoring or health surveillance results show any loss of control.

The Prevention and Control of Exposure to Hazardous Substances

Too often, measures to control workers' exposure to dangerous substances are taken on an 'ad-hoc' basis. Existing processes, procedures and routines are taken for granted, and 'end-of-pipe' solutions are installed. In many cases, workers rely on the use of personal protective equipment. This may lead to sub-optimal levels of control, for example, because the controls are poorly integrated into the process, or because they are difficult to use for workers. The hierarchy of controls supports the identification of a range of control options that tackle the problem in a more fundamental manner.

The Hierarchy of Control is a list of control measures, in priority order, that can be used to eliminate or minimise exposure to the hazard. The hierarchy typically consists of Elimination, Substitution, Engineering controls, Administrative controls with Personal protective equipment as the last line of defence.



The ILO Code of Practice "Safety in the use of chemicals at work" (chapter 6.4) states:

"Employers should include in their assessment consideration as to whether the risks from the hazardous chemicals used can be eliminated by:

- ceasing to use the chemicals;
- replacing them by less hazardous chemicals or by the same substances in a less hazardous form...
- Using an alternative process."

The code of practice goes on to state (chapter 6.5):

"Control measures to provide protection for workers could be any combination of the following:

(a) good design and installation practice:

(i) totally enclosed process and handling systems;

(ii) segregation of the hazardous process from the operators or from other processes;

(iii) plants, processes, or work systems, which minimise the generation of, or suppress or contain, hazardous dust, fumes, etc. and which limit the area of contamination in the event of spills and leaks;

(iv) partial enclosure, with local exhaust ventilation;

(v) local exhaust ventilation;

(vi) sufficient general ventilation;

(b) work systems and practices:

(i) reduction of the numbers of workers exposed and exclusion of non-essential access;

(ii) reduction in the period of exposure of workers;

(iii) regular cleaning of contaminated walls, surfaces, etc.;

(iv) use and proper maintenance of engineering control measures;

(v) provision of means for safe storage and disposal of chemicals hazardous to health;

(c) personal protection:

(i) where the above measures do not suffice, suitable personal protective equipment should be provided until such time as the risk is eliminated or minimised to a level that would not pose a threat to health;

(ii) prohibition of eating, chewing, drinking and smoking in contaminated areas;

(iii) provision of adequate facilities for washing, changing and storage of clothing, including arrangements for laundering contaminated clothing;

(iv) use of signs and notices;

(v) adequate arrangements in the event of an emergency"

The ILO code of practice "Ambient factors in the workplace" (chapter 4.3) has similar requirements.

Elimination

Elimination means a complete removal of the use of dangerous substances from the process in question. Employers will need to adopt a wider approach to the issue to be perceptive to potential options for elimination. Instead of looking at the substance or product in question, employers should look at the work process and function that must be fulfilled by that product or substance. To that end, having an innovative attitude, or at least being sensitive to alternatives will be helpful. Examples of such an approach are:

Mechanical Fixation

Parquet flooring is often installed by gluing, for which either solvent-based or one- or two-pack polyurethane adhesives are used. Instead, so-called floating floors with a 'click' fixation system exist as well, which are not glued. More and more, carpets are installed without glue as well, or they are only glued at the edges, thus providing partial elimination of the use of adhesives, and of the use of solvents when replacing the carpet. Similarly, bitumen roofing may either be installed by using adhesives and by melting (which generates fumes), or by using the weight of grit.

Cleaning and Disinfection

Micro-fibre cloths have specifically been designed to be able to pick up dirt, thus reducing or eliminating the need to use water and detergents.

Sterilisation of medical equipment may be done with the help of formaldehyde or ethylene oxide, or by heating in an autoclave.

In the meat processing industry, removing dirt as quickly as possible reduces the need for using disinfectants, thus providing partial elimination.


Design and Fitting

The production of well-designed concrete elements in a precast concrete factory may reduce the need for activities like drilling, sawing, etc. at construction sites, and prevents exposure to crystalline silica.

In many cases, electric forklift trucks may be employed instead of diesel or gas powered forklift trucks. This eliminates the exposure to (diesel) motor emissions. In the Netherlands, the use of electric forklifts is obligatory inside buildings, for applications up to a lifting power of 4 ton.

Substitution

Substituting a substance or product may involve changes of the (chemical) composition, the 'form' or appearance, or the product's packaging. Generally, it is advisable to consult multiple suppliers to find out about the possibilities.

As far as the product composition is concerned, substitution may reduce the hazard ('harmfulness') of the product or substance used, reduce its exposure potential, or both. An example of the latter is the substitution of dibasic esters for methylene chloride as a paint stripper. Dibasic esters are less toxic (hazardous), but also less volatile than methylene chloride, so the exposure is lower too.

Examples of products that mainly reduce exposure are:

- Low-chromate cement, which reduces dermal exposure to sensitizing chromates.
- The use of lower-temperature asphalt, which reduces inhalation exposure to hazardous and irritating fumes.

An example of hazard reduction is the substitution of so-called 'acid' permanent waving solutions that contain glyceryl monothioglycolate which has been known for a long time as being a strong sensitizer. Alkaline permanent waving solutions contain ammonium thioglycolate instead, which is considerably less sensitising.

A change of the product 'form' may reduce the exposure potential, for instance by changing from a powder to granules, which reduces the inhalation of dust. Examples include:

- Plant protection products (pesticides).
- Construction materials such as tiling adhesives or mortars.
- Animal feed.

Another opportunity is to supply a product in solution instead of as a powder, or to coat the particles with a layer of a less hazardous material. This type of coating has been used for enzymes in detergent factories and is currently considered for nano-materials as well. For example, titanium dioxide nano-particles in sunscreens are coated with aluminium oxide or silica to reduce surface reactivity and thus, dermal risks.

Finally, a well-designed packaging may reduce or even prevent exposure. Two-component reactive coatings, adhesives or fillers may contain irritating or strongly sensitising substances. This is the case for epoxy products, for example. Packages are available that allow mixing the components inside the packaging and in pre-set mixing ratio, without any chance of exposure during mixing. Another well-known example is the water-soluble packaging for e.g. dishwashing tablets or pesticides.

Process Adaptation

If elimination or substitution is not possible for technical reasons, process adaptation may be an option to reduce the release of substances at the source. This may also be a solution when exposure occurs to process-generated substances, such as wood dust, silica, flour dust.

Careful consideration of tasks and activities may indicate opportunities to prevent the release of substances. For example, by reducing the amount of 'energy' put into the process: reducing the dropping height of dusty products from transportation belts (e.g. animal feed, harvested products) may considerably reduce the exposure to dust and toxins from bacteria.

Similar reductions of exposure may be the result when bags are carefully emptied, without shaking. For example, bags of flour that are handled by bakers.

Cleaning activities are another obvious example: vacuum cleaning or wet cleaning instead of wiping or even the use of compressed air prevent the dispersion of and exposure to dust. Preventing exposure to dust, or fibres can also be achieved by cutting materials instead of sawing them.

Control

Control equipment comes in many forms. It includes ventilation (to extract dust, mist, and fumes), glove boxes and fume cupboards, spray booths, and refuges (clean rooms in dirty work areas). It also includes using water to reduce dust and systems for disinfecting cooling water.

Once you've got control, you need to keep it. As the employer, you must make sure that the control measures (equipment and the way of working) keep working properly.

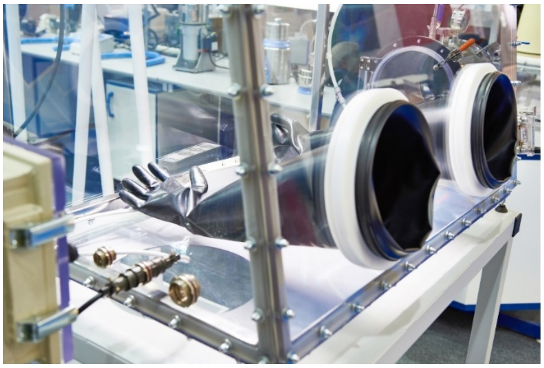
You should name someone to oversee checking and maintaining control measures. It could be you, or someone you appoint, if they know what they need to do, and are able to do it. That is, they are 'competent' to:

- Check that the process isn't emitting uncontrolled contaminants.
- Check that the control equipment continues to work as it was designed.
- Check that workers follow the right way of working.

Good Design and Installation Practice

Enclosure

If a hazardous substance or work process cannot be eliminated or substituted, then enclosing it so workers are not exposed to the hazard is the next best method of control. Many hazards can be controlled by partially or totally enclosing the work process. Highly toxic materials that can be released into the air should be totally enclosed, usually by using a mechanical handling device or a closed glove system that can be operated from the outside.



Whole areas of a plant can be "enclosed" by requiring workers to operate those areas from a control room. Enclosing hazards can minimise possible exposures but does not eliminate them. For example, maintenance workers who service or repair these "enclosed" areas can still be exposed. To prevent maintenance workers from being exposed, other protective measures (such as protective clothing, respirators, proper training, medical surveillance, etc.) must be used, as well as safety procedures.

Isolation

Isolation can be an effective method of control if a hazardous job can be moved to a part of the workplace where fewer people will be exposed, or if a job can be changed to a shift when fewer people are exposed (such as a weekend or midnight shift). The worker can also be isolated from a hazardous job, for example by working in an air-conditioned control booth.

Whether it is the job or the worker that is isolated, access to the hazardous work area should be limited to as few people as possible to reduce exposures. It is also important to limit the length of time and the amount of a substance(s) to which workers are exposed if they must work in the hazardous area. For example, dust-producing work should be isolated from other work areas to prevent other workers from being exposed. At the same time, workers in the dusty areas must be protected and restricted to only a short time working in those areas.

Local Exhaust Ventilation (LEV)

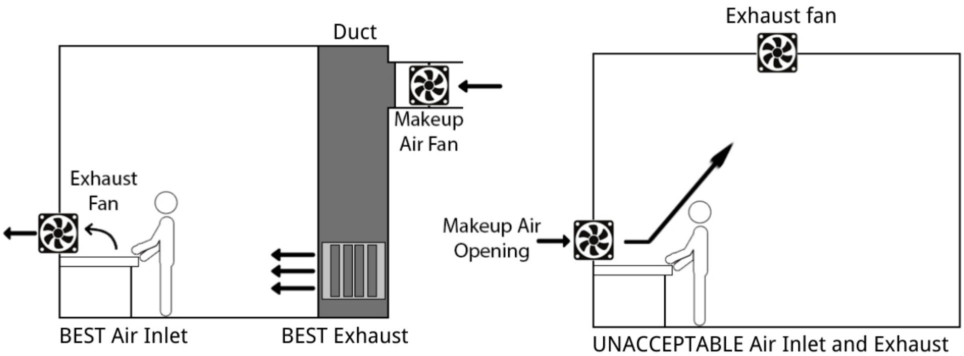
Local exhaust ventilation (LEV) usually uses suction, based on the principle of a vacuum cleaner, to remove pollutants from the air at source, into a ducting, through a filter device (to remove contaminants) and out through a discharge point to the atmosphere. There are many types of LEV, including:

- LEV used for welding fume (captor hood).
- That used in a paint spraying booth (a partial or total enclosure).
- That used in degreasing baths.

General Ventilation

General (or dilution) ventilation is generally used for keeping the workplace comfortable and is one of the least effective methods of controlling hazards but one of the most commonly used. The purpose of any general ventilation system is to remove contaminated air and replace it with "fresh" air. This system does not really remove hazardous agents from the air. It simply reduces the amounts in the air to levels that are considered "safe" for breathing. The effectiveness of a general ventilation system depends on several things, including:

- How quickly the hazardous agent is being released into the air.
- How much and how quickly fresh air is coming in.
- How the contaminated air is being removed.



When used to control chemical pollutants, general ventilation must be limited to only those situations where the amounts of pollutants generated are not very high, where their toxicity is relatively moderate and where workers do not carry out their tasks in the immediate vicinity of the source of contamination. If these injunctions are not respected, it will be difficult to obtain acceptance for adequate control of the work environment because such high renewal rates must be used that the high air speeds will likely create discomfort, and because high renewal rates are expensive to maintain.

Work Systems and Practices

Work practices, usually in the form of procedures, are used to support rather than replace engineering controls. They might include:

Reducing worker exposure: This can be done by either limiting the number of workers where there are highly toxic substances in use (such as biological laboratories) and excluding non-essential personnel, or reducing the time of exposure to workers (by job rotation, for example).

Good housekeeping, cleaning, storage, disposal, and hygiene:

- Ensuring that spillages are promptly dealt with and disinfection is carried out where appropriate.
- Proper storage of chemicals (for example, replacing lids on containers when not in use).
- Prompt and effective waste disposal procedures.
- Ensuring that good hygiene is practiced, particularly before eating, drinking or smoking, and prohibiting eating drinking and smoking in contaminated areas.

Use and proper maintenance of engineering control measures:

- Ensuring that workers are trained in the use of engineering (and other) control measures.
- Making sure that engineering control measures are maintained by competent persons at regular intervals (such as those laid down by law, or recommended by manufacturers).

Personal Protection

Personal protective equipment (PPE) is the least effective method of controlling occupational hazards and should be used only when other methods cannot control hazards sufficiently. PPE can be uncomfortable, can decrease work performance and can create new health and safety hazards. For example, ear protectors can prevent you from hearing warning signals, respirators can make it harder to breathe, earplugs may cause infection, and leaky gloves can trap hazardous chemicals against the skin.

PPE should be acceptable only when your employer cannot control hazards with engineering controls. However, if it is impossible to reduce hazards so that there is no health risk to workers, then PPE must be used.

PPE puts a barrier between the worker and the hazard. PPE may keep the hazard out, but it also keeps heat and water vapour in the protective clothing, which can cause you to be hot and uncomfortable. When wearing PPE, drink plenty of water and take frequent breaks. In hot or humid working conditions, you can only wear PPE for a short time (even as little as ten minutes in very hot conditions) before you need to take a break. Heat and humidity can also decrease the effectiveness of some protective equipment; for example, a respirator mask may not have a tight seal if your face is wet with perspiration or water.

The employer must ensure that workers know when and where PPE must be worn. This can be done at induction, and may be supported by the installation of signs and notices in the workplace to advise workers of the need for a specific type of PPE in a particular area.

Employers must also consider storage of PPE. Facilities must be available for the separate storage of contaminated PPE (such as overalls) and personal clothing when changing. Additionally, there should be arrangements in place for the cleaning of PPE (such as laundering of overalls) and the cleaning of shared PPE (such as breathing apparatus).

Washing facilities should be made available for workers before breaks and at the end of the work periods. Facilities can range from simple hand wash to showering facilities where whole body contamination might be expected (for example internal vessel/tank cleaning activities). Specialist activities, such as asbestos removal, will require decontamination facilities for the workers involved.

A final consideration is actions to be taken in the event of an emergency. For example, on an offshore platform workers may be required to put on survival suits before leaving the platform. In the event of a gas leak on a chemical plant workers may be required to put on breathing apparatus when investigating the leak.

9.6: Epidemiology and toxicology

Human epidemiological investigations

Epidemiology is the study of patterns of disease in human populations. Because epidemiological studies look directly at humans rather than extrapolate from animals, they provide the most compelling evidence for measuring environmental risks to humans.

Most studies in recent decades that have linked environmental factors to human diseases were designed using principles of epidemiology.

Epidemiological studies have provided the critical evidence to link:

- Leukaemia to on-the-job exposures to benzene.
- Heart attacks to cholesterol.
- Lung cancer, heart attacks, and low birth weight to cigarette smoking.
- Legionnaires' disease to contaminated cooling units.

Epidemiological studies provide evidence, not proof. Uncertainty is inherent in the tools that epidemiologists use. While the uncertainty can be very small, it can never be zero, because epidemiologists cannot be sure that the effect they see corresponds to the suspected cause.

Epidemiologists compare two or more groups of people to determine what characteristics distinguish groups who get disease from groups who do not. These distinguishing characteristics are then examined to determine how and why they are associated with disease.

Some of the characteristic's epidemiologists look at are:

- Consumption of certain foods.
- Contact with bacteria, chemicals, or viruses.
- Gender, race, or socioeconomic status.
- Daily activities and behaviours.
- Genetic background.
- Metabolic characteristics, such as cholesterol level and blood pressure.

Epidemiologists favour two types of studies for searching out risk factors for disease, case-control studies, and cohort studies.

Case-Control Studies

Epidemiologists survey a group of people with disease (cases) and a group without disease (controls) about their histories. These are also called "retrospective" studies. The survey may involve direct questioning or examination of medical or other records.

The basic question: What differs in the histories of these two groups that could explain why one is diseased and the other is not?

Example of a case-control study (Taken from the US Centers from Disease Control and Prevention)

In the spring of 1980, U.S. doctors diagnosed hundreds of cases of toxic shock syndrome (TSS), a potentially fatal, previously rare disease. Most cases occurred in young women during their menstrual periods. Investigators at the Centres for Disease Control questioned 50 women with toxic shock syndrome (cases) about their use of sanitary products in the month before they got sick. Then they asked each woman for the names of three friends who did not have TSS (controls) and asked them the same questions. Women with TSS were more likely than their friends to have used tampons. They were almost 8 times as likely to have used one brand: Rely. This brand was withdrawn from the market in September 1980, and the incidence of TSS decreased dramatically.

Cohort Studies (Follow-up Studies)

A cohort study, also called a "prospective" study, begins with a group of people who do not have the disease being studied. Group members differ on one or more characteristics suspected of causing the disease (for example, some may smoke while others do not). The group is followed over time to see if members with the suspect characteristic are more likely to develop the disease.

The basic question: Are the people with the suspect characteristic at greater risk of getting disease?

Example of a cohort study: To evaluate the effect of environmental lead exposure on children's IQs, researchers followed 516 children in the lead-smelting town of Port Pirie, Australia, from birth to age seven, periodically taking blood samples to measure lead levels. At age seven, children with highest blood lead levels over the years had the lowest IQs.

Contrast of studies

Case-control studies are more common than cohort studies because they are faster and cheaper. Also, for relatively uncommon diseases like childhood leukaemia, they often are the only practical way to look for causes of disease.

Cohort studies are more convincing for two reasons:

- They provide a much better opportunity to establish a cause-effect relationship because they begin with the exposure (cause) and move forward in time to the disease (effect). In contrast, case-control studies begin with the disease (effect) and look back to the exposure (cause). It is not always clear that the identified cause actually did come first.
- Case-control studies are more prone to certain study design problems, such as bias or chance.

Drawbacks of cohort studies:

- They are very expensive.
- They take a long time (because they start with healthy people and wait for them to get sick).
- They are difficult to conduct properly because study subjects tend to drop out of the study over time.

The Role of Toxicological Testing

Vertebrate Animal Testing

Animals with an internal skeleton made of bone are called vertebrates. Vertebrates include fish, amphibians, reptiles, birds, mammals, primates, rodents, and marsupials.

Animal experimentation is the use of animals in scientific research. Animal experiments help scientists understand diseases that afflict animals and humans. Scientists also use animal experiments to test new treatments for human and animal diseases, for example new medicines or new surgical techniques.

Experimental research with animals is usually conducted in universities, medical schools, pharmaceutical companies, defence establishments, and commercial facilities that provide animal-testing services to industry. The focus of animal testing varies on a continuum from pure research, done with little regard to the uses to which understanding may be put, to applied research, which may focus on answering some question of great practical importance, such as finding a cure for a disease. Examples of applied research include testing, breeding, defence research, and toxicology. In education, animal testing is sometimes a component of biology or psychology courses. The practice is regulated to varying degrees in different countries.

In the U.S. under the provisions of the Animal Welfare Act and the Guide for the Care and Use of Laboratory Animals (Eighth Edition) published by the National Academy of Sciences, any procedure can be performed on an animal if it can be successfully argued that it is scientifically justified. In general, researchers are required to consult with the institution's veterinarian and its Institutional Animal Care and Use Committee (IACUC), which every research facility is obliged to maintain. The IACUC must ensure that alternatives, including non-animal alternatives, have been considered, that the experiments are not unnecessarily duplicative, and that pain relief is given unless it would interfere with the study. The IACUCs regulate all vertebrates in testing at institutions receiving federal funds in the USA.

In the U.S.A, the numbers of rats and mice used is estimated to be between 20 and 100 million a year. Other rodents commonly used are guinea pigs, hamsters, and gerbils. Mice are the most used vertebrate species because of their size, low cost, ease of handling, and fast reproduction rate. Mice are widely considered to be the best model of inherited human disease and share 99% of their genes with humans. With the advent of genetic engineering technology, genetically modified mice can be generated to order and can provide models for a range of human diseases. Rats are also widely used for physiology, toxicology, and cancer research, but genetic manipulation is much harder in rats than in mice, which limits the use of these rodents in basic science.

There are several different types of acute toxicity tests used. The LD50 ("Lethal Dose 50%") test is used to evaluate the toxicity of a substance by determining the dose required to kill 50% of the test animal population. This test was removed from OECD international guidelines in 2002, replaced by methods such as the fixed dose procedure, which use fewer animals and cause less suffering. Abbott writes that, as of 2005, "the LD50 acute toxicity test ... still accounts for one-third of all animal [toxicity] tests worldwide."

Irritancy can be measured using the Draize test, where a test substance is applied to an animal's eyes or skin, usually an albino rabbit. For Draize eye testing, the test involves observing the effects of the substance at intervals and grading any damage or irritation, but the test should be halted and the animal killed if it shows "continuing signs of severe pain or distress".

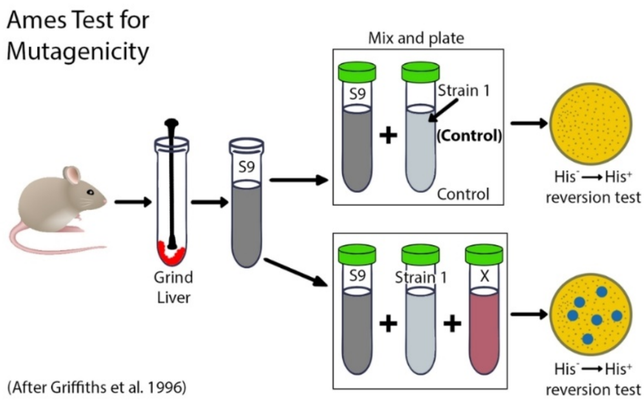
Ames Test

The Ames test is a widely employed method that uses bacteria to test whether a given chemical can cause mutations in the DNA of the test organism.

It assesses the mutagenic potential of chemical compounds. A positive test indicates that the chemical is mutagenic and therefore may act as a carcinogen, because cancer is often linked to it.

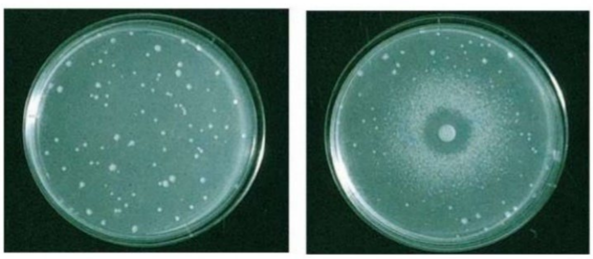
The Ames Test combines a bacterial revertant mutation test with a simulation of mammalian metabolism to produce a highly sensitive test for mutagenic chemicals in the environment.

A rat liver homogenate is prepared to produce a metabolically active extract (S9, see diagram below. The extract is combined with a strain of his-Salmonella bacteria: in the absence of histidine (a basic amino acid found in the diet of vertebrates), the bacteria are unable to grow on minimal medium (control result). The homogenate and bacterial strain are combined with a suspected mutagenic substance (X). The induction of revertant colonies indicates that some his-bacteria have mutated (reverted) to his+, and therefore that substance X is a mutagen. Different bacterial strains are sensitive to different types of mutation.



Initial experiments used the reversion test without a liver homogenate. However, mutagenicity, unlike toxicity, is not the result of ingestion of a suspect substance, but rather its accumulation and that of its breakdown products in the body. Use of a liver homogenate simulates the metabolic breakdown of the suspected mutagen in a mammalian system, and more accurately predicts mutagenicity of substances ingested by humans. For example, sodium nitrate (NaNO3), which occurs naturally in smoked meats such as bacon, hot dogs, ham, etc. is not itself mutagenic. However, when acted upon by HCl in the stomach, it is converted to nitrous acid (HNO2), which has been demonstrated to be a powerful mutagen by the Ames Test.

The Ames test results



The dish on the left (above) was plated with ~10^9 *his*$^-$ *Salmonella* bacteria, which cannot grow in the absence of the amino acid histidine. In this control experiment, the small number (~10^2) of white colonies are derived from single bacteria that have undergone *spontaneous* reversion mutations to *his*$^+$. The reversion test is thus extremely sensitive, because it can detect mutation rates as small as $1/10^{9-2} = 10^{-7}$/ cell.

In the experiment on the right, the disc at the centre of the dish contains a mutagenic chemical. As it diffuses outward, the chemical at high concentration is toxic and at first kills all the bacteria (clear circle around the disc), but at lower concentrations gives rise to *induced* reversion mutations, seen as closely-packed revertant (*his*$^+$) colonies. As the concentration continues to decrease towards the outer periphery of the plate, the frequency of revertant colonies falls to about the same as in the control experiment at left. In cell culture, it is therefore possible to measure the precise degree of mutagenicity at a range of concentrations.

Qualitative and Quantitative Structure Activity Relationship (QSAR)

Structure-Activity Relationship (SAR) is an approach designed to find relationships between chemical structure (or structural-related properties) and biological activity (or target property) of studied compounds. As such it is the concept of linking chemical structure to a chemical property (e.g. water solubility) or biological activity including toxicity (e.g. fish acute mortality). Qualitative SARs and quantitative SARs, collectively are referred to as (Q)SARs. Qualitative relationships are derived from non-continuous data (e.g. yes or no data), while quantitative relationships are derived for continuous data (e.g. toxic potency data).

The central axiom of SAR is that the activity of molecules is reflected in their structure. Hence, similar molecules have similar activities. The SAR approach therefore assumes that the structure of a molecule (e.g. its geometric, electronic properties, etc.) contains the features responsible for its physical, chemical, and biological properties. It relies on the ability to represent the chemical by one or more descriptors of which the 2-dimensional structure is one. The underlying problem is how to define differences at the molecular level since each kind of activity might depend on different molecular similarities.

Biological activity (e.g. toxicity) of substances is governed by their properties, which in turn are determined by their chemical structure. The objectives of SAR are two-fold. First, to determine as accurately as possible the limits of variation in the structure of a chemical that are consistent with the production of a specific effect (e.g. can a chemical elicit a specific toxic endpoint). Second, to define the ways, which alterations in structure and thereby the overall properties of a compound influence endpoint potency.

The development of a (Q)SARs model requires three components:

- A data set that provides activity (usually measured experimentally) for a group of chemicals (i.e. the dependent variable). This group of chemicals is typically defined by some selection criteria.
- Structural criteria or structure-related property data set for the same group of chemicals (i.e. the independent variables).
- A means of relating (usually a statistical analysis method) these two data arrays. Methods for relating structure to activity range from the simple, linear regression, through more complex approaches such as partial least squares analysis to the most complex, machine learning techniques such as neural networks.

Grouping and Read Across

Grouping of Substances

Substances that are structurally similar with physicochemical, toxicological, eco-toxicological and/or environmental fate properties that are likely to be similar or to follow a regular pattern may be considered as a group of substances. These similarities may be due to several factors:

- Common functional group (i.e. chemical similarity within the group).
- Common precursors and/or likely common breakdown products via physical and/or.

- Biological processes which result in structurally similar degrading chemicals.
- A constant pattern in the properties across the group (i.e. of physico-chemical and/or biological properties).

Read Across

For registration of a substance under REACH, for example, the information requirements must be met. Within a group of substances, a data gap might be filled by read across.

The application of the grouping concept described above means that REACH information requirements for physicochemical properties, human health effects and/or environmental effects may be predicted from tests conducted on reference substance(s) within the group, referred to as source substance(s), by interpolation to other substances in the group, referred to as target substance(s), and this is called read across.

Thus, read-across is regarded as a technique for predicting endpoint information for one substance (target substance), by using data from the same endpoint from (an)other substance(s), (source substance(s)). Consequently, the read-across approach must be considered on an endpoint-by-endpoint basis due to the different complexities (e.g. key parameters, biological targets) of each endpoint.

The term analogue approach is used when read-across is employed within a group of a very limited number of substances for which trends are not apparent: i.e. the simplest case is read across from a single source substance to a target substance.

Alternatively, with a higher number of substances in a group the term category approach is used.

Read-across must be, in all cases, justified scientifically and documented thoroughly. There may be several lines of evidence used to justify the read-across, with the aim of strengthening the case.

The Meaning of Dose-Response Relationship

The dose-response relationship, or exposure-response relationship, describes the change in effect on an organism caused by differing levels of exposure (or doses) to a stressor (usually a chemical) after a certain exposure time.

This may apply to individuals (e.g. a small amount has no significant effect, a large amount is fatal), or to populations (e.g. how many people or organisms are affected at different levels of exposure).

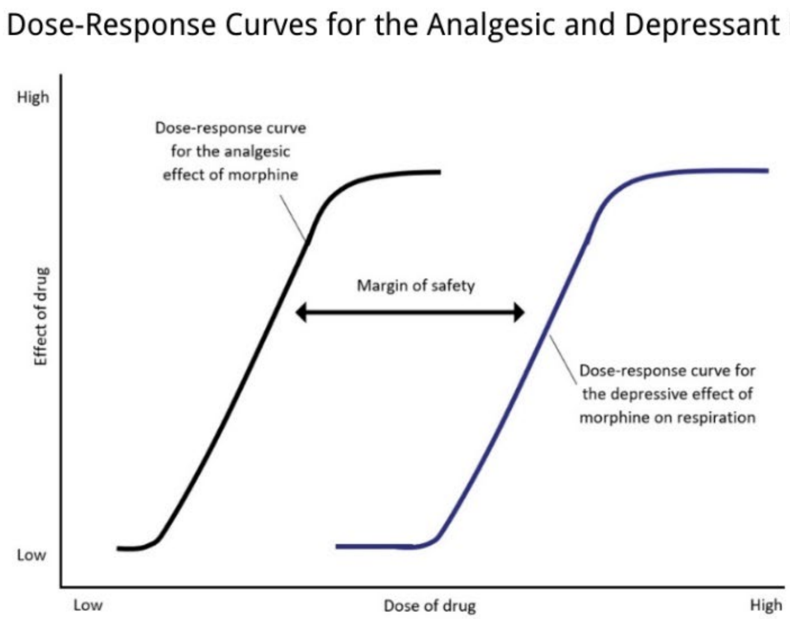
Studying dose response, and developing dose-response models, is central to determining "safe" and "hazardous" levels and dosages for drugs, potential pollutants, and other substances to which humans or other organisms are exposed.

Dose-response relationships generally depend on the exposure time and exposure route (e.g. inhalation, dietary intake), quantifying the response after a different exposure time or for a different route leads to a different relationship and possibly different conclusions on the effects of the stressor under consideration. This limitation is caused by the complexity of biological systems and the often-unknown biological processes operating between the external exposure and the adverse cellular or tissue response.

A dose-response curve (see below) is a simple X-Y graph relating the magnitude of a stressor (e.g. concentration of a pollutant, amount of a drug, temperature, the intensity of radiation) to the response of the receptor (e.g. organism under study). The response may be a physiological or biochemical response, or even death (mortality), and thus can be counts (or proportion, e.g. mortality rate), ordered descriptive categories (e.g. severity of a lesion), or continuous

measurements (e.g. blood pressure). Several effects (or endpoints) can be studied, often at different organisational levels (e.g. population, whole animal, tissue, cell).

The measured dose (usually in milligrams, micrograms, or grams per kilogram of body weight for oral exposures or milligrams per cubic meter of ambient air for inhalation exposures) is generally plotted on the X axis and the response is plotted on the Y axis.



The first point along the graph where a response above zero (or above the control response) is reached is usually referred to as a threshold-dose. For most beneficial or recreational drugs, the desired effects are found at doses slightly greater than the threshold dose. At higher doses, undesired side effects appear and grow stronger as the dose increases. The more potent a substance is, the steeper this curve will be. In quantitative situations, the Y-axis often is designated by percentages, which refers to the percentage of exposed individuals registering a standard response (which may be death, as in LD50).

NOAEL

The no-observed-adverse-effect-level (NOAEL) is an important part of the non-clinical risk assessment process. The common definition of NOAEL, "the highest experimental point that is without adverse effect," serves us well in general discussions. It does not, however, address the interpretation of risk based on toxicologically relevant effects, nor does it consider the progression of effect with respect to duration and/or dose.

NOAEL denotes the level of exposure of an organism, found by experiment or observation, at which there is not biologically or statistically significant (e.g. alteration of morphology, functional capacity, growth, development, or life span) increase in the frequency or severity of any adverse effects in the exposed population when compared to its appropriate control.

In toxicology, it is specifically the highest tested dose or concentration of a substance (i.e. a drug or chemical) or agent (e.g. radiation), at which no such adverse effect is found in exposed test organisms where higher doses or concentrations resulted in an adverse effect.

This level may be used in the process of establishing a dose-response relationship, a fundamental step in most risk assessment methodologies.

LD50 and LC50

LD stands for "Lethal Dose". LD50 is the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals. The LD50 is one way to measure the short-term poisoning potential (acute toxicity) of a material.

Since different chemicals cause different toxic effects, comparing the toxicity of one with another is hard. We could measure the amount of a chemical that causes kidney damage, for example, but not all chemicals will damage the kidney. We could say that nerve damage is observed when 10 grams of chemical A is administered, and kidney damage is observed when 10 grams of chemical B is administered. However, this information does not tell us if A or B is more toxic because we do not know which damage is more critical or harmful.

Therefore, to compare the toxic potency or intensity of different chemicals, researchers must measure the same effect. One way is to carry out lethality testing (the LD50 tests) by measuring how much of a chemical is required to cause death. This type of test is also referred to as a "quantal" test because it is measuring an effect that "occurs" or "does not occur".

The test substance or preparation may be applied to the animal orally, under the skin, by inhalation, into the abdomen or into the vein. LD50 and LC50 are the parameters used to quantify the results of different tests so that they may be compared.

LD50 is expressed in milligrams per kilogram of body weight of the test animal (which must be mentioned).

The table that follows shows the LD50 values for several test organisms.

Species	Administration route	LD50 Value (in µg/kg)
Rat	Probit analysis*	167
	Intravenous	82.5
	Intramuscular	107
Marmoset	Intravenous	10.0
Guinea Pig	Intravenous	27.5
	Subcutaneous	24.7
	Cutaneous	11.600
Pig	Intravenous	6.0

LC stands for "Lethal Concentration". LC values usually refer to the concentration of a chemical in air but in environmental studies it can also mean the concentration of a chemical in water.

According to the OECD (Organisation for Economic Cooperation and Development) Guidelines for the Testing of Chemicals, a traditional experiment involves groups of animals exposed to a concentration (or series of concentrations) for a set period of time (usually 4 hours). The animals are clinically observed for up to 14 days.

The concentrations of the chemical in air that kills 50% of the test animals during the observation period is the LC50 value.

LC50 is expressed in millilitres per kilogram of body weight of the test animal (which must be mentioned), exposed to the substance by inhalation during a specified period. The variation in the numerical values of LD50 and LC50 is wide.

9.7: Asbestos and Lead

Asbestos

Identification of Types of Asbestos

Breathing in air containing asbestos fibres can lead to asbestos-related diseases, mainly cancers of the lungs and chest lining. Asbestos is only a risk to health if asbestos fibres are released into the air and breathed in. Past exposure to asbestos currently kills around 4500 people a year in Great Britain. Workers who carry out maintenance and repair work are, particularly at risk.

There is usually a long delay between first exposure to asbestos and the onset of disease. This can vary from 15 to 60 years. Only by preventing or minimising these exposures now can asbestos-related disease eventually be reduced.

Two mineralogical groups of asbestos, serpentines, and amphiboles, have been exploited industrially and commercially:

- Serpentines: contain only one variety of asbestos: chrysotile.
- Amphiboles: include five varieties of asbestos: anthophyllite, amosite, crocidolite and tremolite. Only two of them have been widely used: amosite and crocidolite.

It is now illegal to use asbestos in the construction or refurbishment of any premises, but many thousands of tonnes of it were used in the past and much of it is still in place.

Types of asbestos

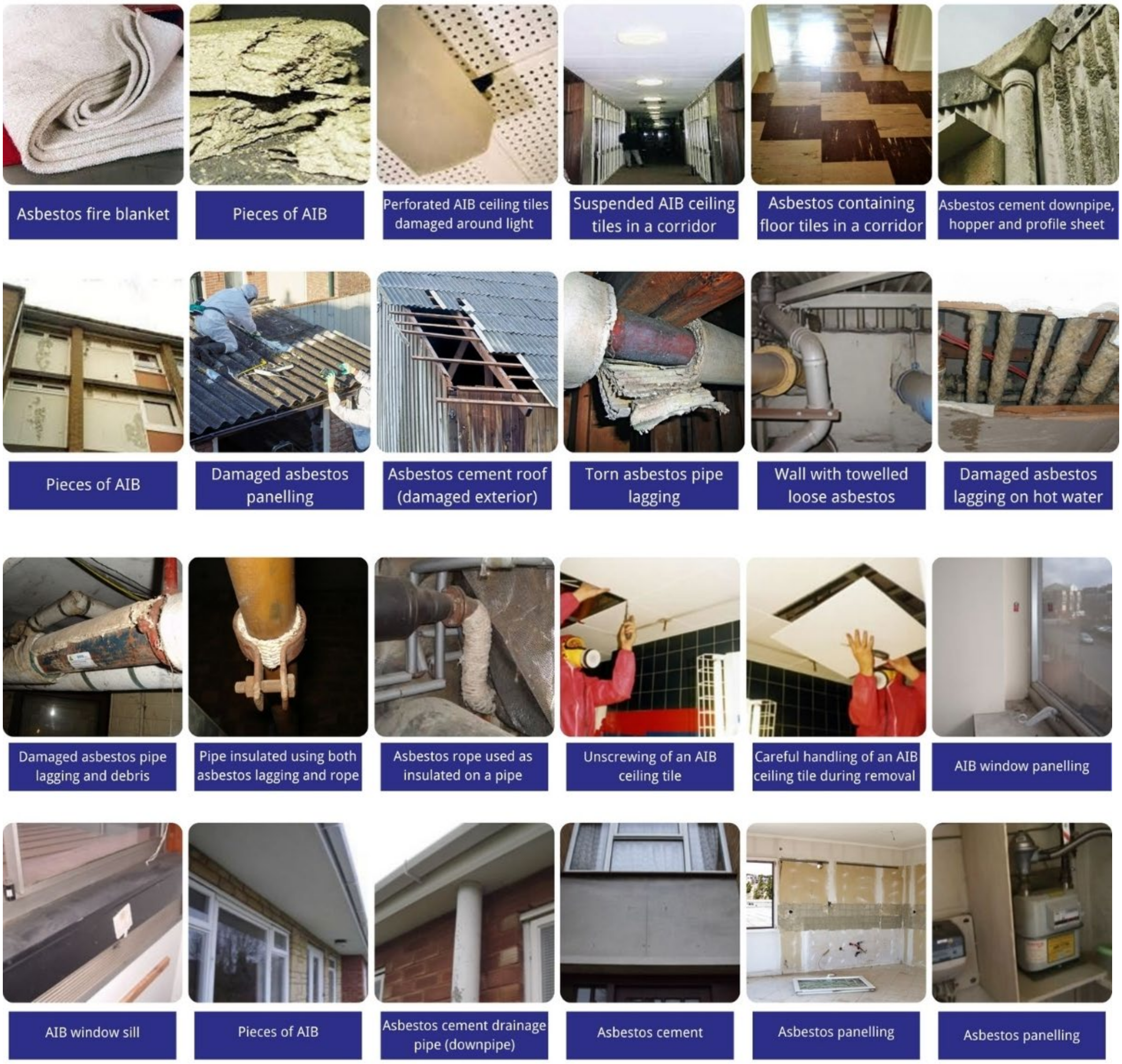
There are three main types of asbestos that can still be found in premises, white, brown, and blue. All of them are dangerous carcinogens, but blue and brown asbestos are considered to be more hazardous than white.

Despite their names, you cannot identify them just by their colour. The only certain way to identify the different types of asbestos is to take a sample and have it examined microscopically.

Asbestos under a microscope

If the presence of asbestos is suspected in a premise, it may be possible to view pictures of common asbestos types to get an idea of what to look for, and where they may be. The pictures below show the different types of asbestos,

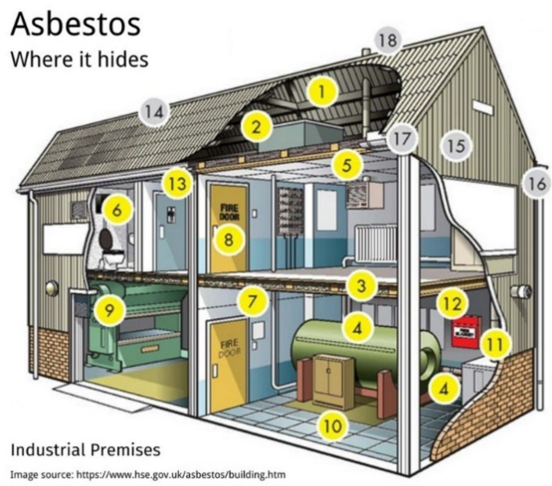
what they look like and where they may be located. This can give you a good idea of places to look for asbestos and how it may look, although final confirmation will only be given after sampling and analysis by a competent person.



Examples of where asbestos can be found.

Typical locations where Asbestos can be found

Commercial or Industrial Premises



Inside:

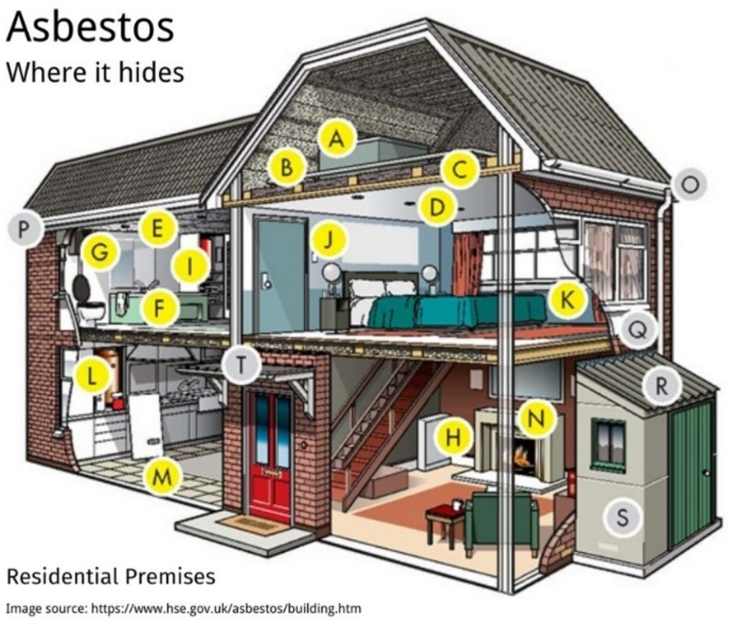
1. Sprayed coatings on ceilings, walls, beams, and columns
2. Asbestos cement water tank
3. Loose fill insulation
4. Lagging on boilers and pipes
5. AIB ceiling tiles
6. Toilet seat and cistern
7. AIB*partition walls
8. AIB panels in fire doors
9. Asbestos rope seals, gaskets, and paper
10. Vinyl floor tiles
11. AIB around boilers
12. Textiles e.g. fire blankets
13. Textured decorating coatings on walls and ceilings (e.g. Artex)

Outside:

14. Asbestos cement roof
15. Asbestos cement panels
16. Asbestos cement gutters and downpipes
17. Soffits - AIB or asbestos cement
18. Asbestos cement flue

1. (*AIB = Asbestos Insulating Board)

Residential Property



Inside:

A. Asbestos cement Water tank
B. Pipe lagging
C. Loose fill insulation
D. Textured decorative coating (e.g. Artex)
E. AIB*ceiling tiles
F. AIB bath panel
G. Toilet seat and cistern
H. AIB behind fuse box
I. AIB airing cupboard and/or sprayed insulation coating boiler
J. AIB partition wall
K. AIB interior window panel
L. AIB around boiler
M. Vinyl floor tiles
N. AIB behind fire

Outside:

O. Gutters and Asbestos cement downpipes
A. Soffits - AIB or asbestos cement
B. AIB exterior window panel
C. Asbestos cement roof
D. Asbestos cement panels
E. Roofing felt

F. (*AIB = Asbestos Insulating Board)

The Control Measures for the Specific Case of Asbestos: Preventative Methods

Introduction

The practical recommendations of the ILO “Safe use of Asbestos” code of practice are intended for the use of all those, both in the public and in the private sectors, who have responsibility for safety and health h in the use of asbestos. The code is not intended to replace national laws or regulations or accepted standards. Local circumstances and technical possibilities will determine how far it is practicable to follow its provisions.

The following preventative and control measures summarise the content of the code of practice.

Preventative and control measures

Alternative materials

Replacement of the material with substances that can be used in the same way and have the same technical requirements but that are either less harmful or harmless. However, any hazards posed by the replacement material must be assessed and controlled independently.

Before replacing or substituting the asbestos, the organisation should assess whether it is practicable in regard to cost and whether it is entirely necessary. In some cases, the asbestos may be located in a location that poses little or no risk and is not at risk of being disturbed. In some buildings, floor tiles made from asbestos were laid in the 1950’s and 60’s. However, in some cases where the tiles are still in good order and not showing signs of disintegrating, it is cheaper, easier, and just as effective to cover with a new covering rather than removing the tiles entirely. This is a decision that must be considered thoroughly before deciding on how to proceed.

Engineering controls

If the asbestos cannot be removed or substituted, then the ILO code of practice states:

"All appropriate and practicable measures of engineering, work practice and administrative control should be taken to eliminate or to reduce the exposure of workers to asbestos dust in the working environment to the lowest possible level.”

Engineering controls can include:

- Mechanical handling
- Ventilation
- Redesigning of a process
- Contain or collect asbestos dust emissions

The ILO code of practice gives prescriptive detail on what this can include:

"…process separation, automation or enclosure;"

This means any processes involving asbestos are:

- Kept separate from other work processes and areas
- Fully automated to eliminate worker contact with asbestos
- Enclosed to restrict any fibres being transferred from the process to other areas

"…general ventilation of the working areas with clean air;

"Ensuring that the air around work areas is well ventilated sufficiently especially where local exhaust ventilation is used - this is covered in more detail later in this section."… local ventilation of processes, operations, equipment and tools for the prevention of dust dissemination;

"Local exhaust ventilation should be used to remove any potential dust using booths or captor hoods. This is covered later in this section."…use of wet methods where appropriate;

"Water or other wet substances can be used to dampen down any materials to reduce any release to the breathable atmosphere."…separate workplaces for certain processes

"Separate areas should be used where there is a danger of any release to the breathable area. In these separate areas, personal protective equipment must be used and decontaminated before leaving.

Control programme

To ensure full control measures are implemented as stated previously, organisations need to have administrative controls in place to ensure that practical measures are communicated to workers and that the control procedures are being carried out correctly.

The administrative control should include:

- Consultation with workers and any representatives.
- Implementation of a control programme.
- Evaluation of each workplace highlighting specific features.
- Controls should be written down.

Exposure to asbestos is extremely hazardous to health even for a short exposure and as such, written control methods need to be as comprehensive as possible. When compiling this information, the following should be included:

Design and Installation

Design of equipment, materials and processes should be such that the possibility of exposing workers to asbestos dust is eliminated or "reduced to the lowest practicable level". As asbestos has been used as insulating material and small parts in equipment such as lathes, grinding machines and conveying systems due to its tolerance for heat, older machinery may still pose a hazard. If this is acquired second hand and installed into a workplace, asbestos controls need to be implemented.

Details of any asbestos dust emissions, the type of asbestos and the level should be provided in writing from manufacturers of any equipment, machinery, and materials. The manufacturers should also include information regarding controls that should be implemented before, during and after use.

Any workplaces should be designed carefully and the ILO code of practice states that they should be:"…built and maintained in such a manner as to:

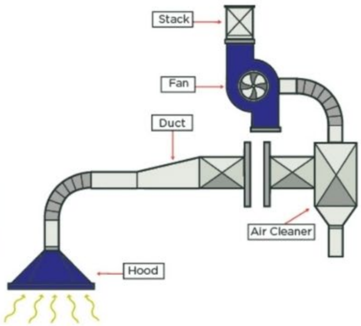
- separate the hazardous operations from the remainder of the premises
- reduce as far as possible surfaces on which asbestos dust and waste may accumulate
- facilitate the cleaning of floors, walls, ceilings, and machinery
- facilitate the collection of asbestos dust which may escape in the event of an incident. "

Any processes where there is a risk of exposure should be totally enclosed where practicable and if this is not a current practice it should be designed and installed. The enclosure should have an internal ventilation system to create negative pressure in the enclosure.

Local Exhaust Ventilation (LEV)

Installation

If the design of a workplace restricts the installation of an enclosure, local exhaust ventilation equipment, specifically designed to catch and remove dust laden air, should be provided, and maintained. The use of booths or captor hoods should be utilised so that the exhaust ventilation system can get as close as possible to the source of the dust emission. The openings in the enclosures should be a small as possible to prevent dust escaping and not hindering the work process.



The ventilation system will create a negative pressure in the work area which will then pull in fresh air from sources such as doors, windows. However, any fluctuations in air flow from workers and the process should not interrupt the extraction of dust from the working atmosphere and so the airflow will need to be tested before work commences.

Personal Protection

In any hierarchy of control methods, personal protective equipment (PPE) is the final control to be implemented to protect against residual risk. It should never be considered as a first line defence against the risks from a hazard.

Any respiratory protective equipment (RPE) and personal protective equipment (PPE) must be provided by the employer and without costs to workers.

PPE should be suitable and sufficient with regards to protection and should be readily available to workers that are likely to come into contact with asbestos or asbestos dust. It is essential that workers are instructed when and where to use PPE for protection from asbestos and that they are aware of the risks from this hazard. Supervision of workers who are required to use PPE for protection against asbestos must ensure that the equipment is used correctly.

Respiratory Protective equipment (RPE)

RPE must be approved and tested by competent authorities who will advise and provide guidelines for when each type should be used. Some of the different types of RPE are given by the ILO code of practice as:

- Air-purifying respirators of the negative pressure (half face mask) type.
- Positive pressure respiratory equipment.
- Direct airline breathing apparatus.

Workers and representatives need to be consulted when selecting the correct RPE and the maximum concentration of asbestos dust should be used to determine which RPE would be the most appropriate.

Workers should be given a choice, where possible, of the most comfortable RPE. In some cases, due to beards especially, an adequate face seal may not be achieved and so a positive pressure RPE may be used but this will not offer the same level of protection as a sealed unit and therefore the worker/s involved must be made aware of the increased risks before agreeing to use.

Training

Workers must receive full instruction on the following:

- Why the equipment must be used
- The importance of using RPE properly and in accordance with instructions
- How to understand and recognise when RPE is required and the circumstances when it will be required
- How the equipment works
- The correct assessment of a face fit and how to check for a seal
- How to check the equipment is operating correctly.
- The importance and need for regular servicing.

A record needs to be kept of any training given showing:

- Date of training
- Workers who were trained
- Details of the instructor
- What information was covered (a checklist is often used here)

Cleaning, maintenance, and storage

Respirators are user specific and so should be kept exclusively for the worker to which they have been supplied. They need to be regularly cleaned and serviced by competent personnel at least once a week. They may require more regular cleaning, depending on the amount of use. On each occasion that the respirators are cleaned, any pre-filters should be changed, and the main filters should be checked. All cleaning and checks should be recorded showing:

- Who was the respirator issued to?
- Dates of cleaning
- Dates of servicing
- Details of who cleaned and/or serviced the equipment
- Details of the clean and/or servicing

For respirators using airline, the integrity of the airline should be checked before each use and valves checked when cleaned and serviced.

After each use, the equipment must be decontaminated and then kept in a secure metal box or plastic bag ready for the next use. It is essential that equipment is not placed into storage without being decontaminated to ensure asbestos does not settle in the inside of the equipment.

If the equipment is disposable, it must be disposed of in the same way as the asbestos due to the contamination.

Disposal of Asbestos Waste

ILO C162 - Asbestos Convention, 1986 requires that asbestos waste be disposed of in accordance with any national laws and practice, in a manner that does not pose a risk to the workers concerned, including those handling the waste, or to any persons in the nearby vicinity of the disposal process. Detailed advice on disposal procedures can be found in the ILO “Safe use of Asbestos” code of practice, which supports:

- C162 Asbestos Convention 1986
- R172 Asbestos Recommendation 1986
- Resolution concerning asbestos 2006

All the above can also be found on the ILO website: www.ilo.org .In Europe, guidance is taken from the guide issued by the Senior Labour Inspectors Committee. The full guide can also be downloaded from the ILO website.

In the UK, guidance is taken from the HSE - the enforcing authority for health and safety in England, Scotland Northern Ireland, and Wales.

Use of Specialist Contractors for Removal and Disposal of Asbestos

Selecting a Competent Surveyor

Accreditation or certification provides clients with an assurance of a surveyor's competence.

Competent surveyors:

- Have survey knowledge and know the risks in surveying.
- Have training and experience and recognise their limitations.
- Use a quality management system.
- Show independence, impartiality, and integrity.
- Do their work in accordance with good practice guidance, (for example, as in ILO "Safety in the Use of Asbestos").

Checking competence of specialist contractors

For the client who is seeking a contractor, it is important to consider the technical standards of contractors’ proposals for preventing the risks of:

- Spread of asbestos contamination.
- Exposure to others during the course of the works.
- Providing adequate records to enable subsequent monitoring and maintenance of any encapsulated or enclosed materials to be efficient and effective.

The upheaval involved in asbestos encapsulation or removal is clearly substantial. Therefore, it is important that the area should be thoroughly surveyed so that all asbestos-containing materials can be dealt with at the same time.

For the people involved in the building design and services (architects, civil engineers, building facilities managers), the planning of the asbestos work may involve taking account of all services that might need to be re-routed or provided:

- Water, gas, electricity, central heating, air conditioning, ventilation, fire alarms - may need to be altered so that the building as a whole can function safely during the asbestos works.
- Water, gas, electricity, drainage, telephone, may need to be provided for the asbestos works.

If you employ or control people who are involved in some capacity with work on materials that contain asbestos, you should:

- Ensure that they understand their role with respect to preventing and minimising exposure for themselves and/or for others.
- Ensure that any retained asbestos-containing materials are monitored, managed, and properly maintained.
- Ensure that any potential contractors' technical proposals demonstrate high standards in controlling and preventing asbestos exposure.
- Ensure that you fulfil requirements under national regulations and legislation, e.g. sub-contractors may need to hold licences in some member states.

In some states or countries where higher-risk work with asbestos must only be done by a licensed contractor, the member state will have a licensing system.

As an example, in the UK, the HSE Asbestos Licensing Unit (ALU) operates a "permissioning regime" that issues licences to carry out licensable work with asbestos as required by regulation 8 of The Control of Asbestos at Work Regulations 2012.

For a licence to be granted, applicants need to demonstrate that they have the necessary skills, competency, expertise, knowledge, and experience of work with asbestos, together with effective health and safety management systems.

Holding a licence incurs serious responsibilities, particularly at a senior management level.

A licence acts as a 'permit to work' with asbestos following a successful licence assessment interview. Applying for a licence to work with asbestos (or renewing a licence) requires:

- Thorough preparation.
- A commitment to continuous improvement.
- The demonstration of organisational and individual competence.
- An extensive knowledge of the industry.
- A willingness to be accountable for your company's performance.
- The provision of evidence of effective health and safety management systems.

Licences are issued for a fixed period of time (between 1 and 3 years), after which they need to be renewed. At renewal, performance as recorded following inspections by HSE inspectors and local authority officers will also be taken into account.

To assist clients, and others, when selecting Contractors for high-risk work with asbestos (such as removal, and disposal) the HSE website lists all of those Contractors who are currently licensed. Only contractors on the list should be used for higher risk work involving asbestos. In addition, Contractors should be vetted for their overall health and safety management standards (for example quality of HSE policy; employee HSE training; previous work recommendations; previous enforcement actions.).

In additional, membership of a professional trade body can help assess the quality and competence of prospective Contractors - for example, membership of the Asbestos removal Contractors Association (ARCA.)

Additional Control Measures for Working with Lead

Introduction

Lead is a soft, blue-grey metal. It is found at low concentrations in the earth's crust predominantly as lead sulphide (galena), but the widespread occurrence of lead in the environment is largely the result of anthropogenic (human) activity. The utility of lead and lead compounds were discovered in prehistoric times.

Lead has been used in plumbing and tableware since the time of the Roman Empire. Lead usage increased progressively with industrialisation and rose dramatically with the widespread use of the automobile in the twentieth century. Lead has found major uses in pipes and plumbing, pigments and paints, gasoline additives, construction materials, and lead-acid batteries. The uses of lead in pipes, paints, and gasoline additives have resulted in substantial introductions of lead into the environment and human exposure and are being phased out in many countries. The predominant use of lead is now in lead-acid batteries and, to a lesser extent, in construction materials and lead-based chemicals.

Lead exists in both organic and inorganic forms:

Inorganic Lead

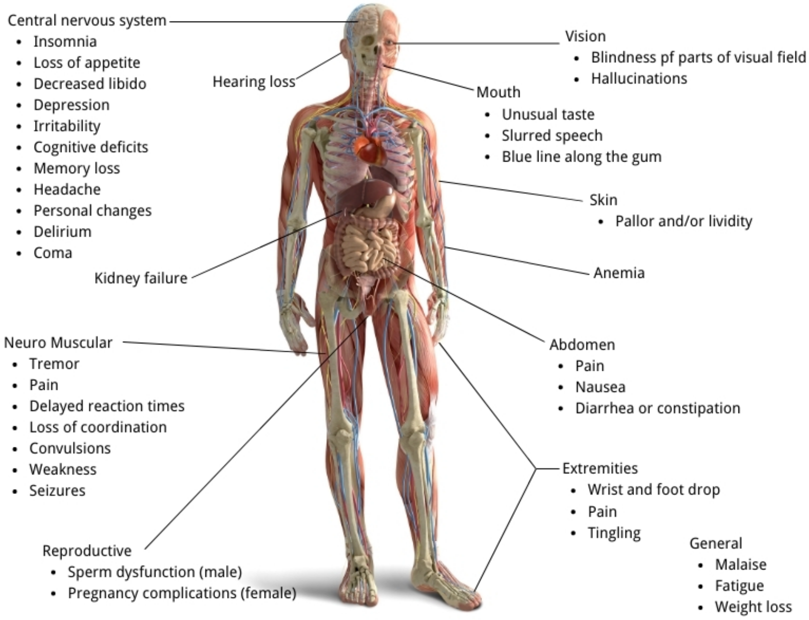
The most important routes of absorption of inorganic lead are ingestion via the gastrointestinal tract (often because of poor hygiene, not washing hands before eating and drinking after handling lead) and inhalation of dust, fumes, or vapour into the lungs. The effects are cumulative (lead is not easily excreted from the body). If lead levels get too high it can cause symptoms such as dizziness, tiredness, cramps, headaches even and anaemia. Continuous uncontrolled exposure can cause more serious symptoms such as kidney damage, nerve and brain damage, infertility.

Organic Lead

Organic lead compounds such as tetra-ethyl and tetra-methyl lead appreciably declined with the demise of leaded petrol (as of June 2016, only Algeria, Yemen and Iraq continued widespread use of leaded gasoline). Potential higher exposure concerned activities involving the blending of the lead into gasoline and in the cleaning out of leaded gasoline storage tanks.

Organic lead can enter the body through inhalation or ingestion. It is also readily absorbed through the skin.

Acute exposure to a high level over can cause intoxication, as can lower exposures over a longer period of time. Milder effects include tiredness, wild dreams, anxiety, trembling and loss of appetite. More severe intoxication causes episodes of disorientation, hallucinations and intense activity which may require an individual to be restrained. The episodes may convert in convulsive seizures, which may end in unconsciousness or death.



Effects of lead on the body.

The ILO has little specific information on working with lead but does cover the risks of working with lead in its document "Safety and health in the non-ferrous metals industries".

"Absorption of lead occurs mainly via the lungs and by ingestion. Short-term (acute) exposure to inorganic lead can lead to vague symptoms such as headache, fatigue, nausea, abdominal cramps and constipation. Long-term (chronic) exposure causes anaemia and peripheral motor neuropathy. Renal damage and encephalopathy have been described mainly in children and young people. Lead may also impair fertility and cause harm to the unborn child".

Specific information can be found on the UK's HSE website.

The HSE advises that workers are most at risk when work produces lead dust, fume, or vapour. This can include:

- Blast removal and burning of old lead paint
- Stripping of old lead paint from doors, windows, etc
- Hot cutting in demolition and dismantling operations
- Scrap-processing activities, including recovering lead from scrap and waste
- Lead-acid battery manufacture, breaking, and recycling
- Some painting of buildings
- Some spray-painting of vehicles
- Working with metallic lead and alloys containing lead, e.g. soldering
- Lead smelting, refining, alloying, and casting
- Manufacturing and physically processing (e.g. bagging) lead compounds
- Manufacturing leaded glass
- Manufacturing and using pigments, colours, and ceramic glazes
- Recycling of any materials containing lead (e.g. cables, TVs or computer monitors containing cathode ray tubes (CRT))

Control measures for working with lead should be designed to prevent inhalation of dust or fumes and prevention of ingestion. Prevention and control are achieved via the following methods:

1. Work Method

Workers should limit the amount of dust or fume that are created. Use of one or more of the following should be considered:

- Chemical paint stripper to avoid dust when stripping lead coatings.
- Wet abrasive paper and scraper to dampen down any dust removed when sanding or stripping lead based products.
- An "on tool extraction" method where dust is diverted away in a similar way to a captor hood but on a scale relevant to the tool. In these cases, the tools are fitted with the unit.

Figure 1 Tools and accessories providing for effective dust removal

Image source - https://www.hse.gov.uk/pubns/cis69.pdf

2.Respiratory Protective Equipment (RPE)

RPE should have a suitable and sufficient protection factor in the filtration section. For longer duration work powered RPE with the same protection should be considered. RPE needs to be compatible with other protective equipment and fit testing is needed for tight fitting masks. People wearing RPE need to be clean-shaven in order for the seal to fit correctly.

3. Preventing spread

Additional controls to prevent dust or fume spreading e.g. plastic sheeting should be used to separate and cover surfaces. Any soft furnishings in the vicinity should be protected and surfaces should be cleaned thoroughly after the work is complete. All contaminated waste needs to be disposed of safely with particular attention to keeping children and pregnant women away from the work area.

4. Clothing

Disposable coveralls and washable (e.g. PVC) or disposable gloves are required if there is likely to be lead dust contamination. They should be removed when leaving the work area. Protective clothing must not be worn in rest areas and must be kept away from personal clothing worn outside of work. Any contaminated clothing should not be washed at home.

5. Washing

Washing is an important control. In many cases, standard site welfare facilities will be sufficient. Workers need to be instructed that they should ensure that they:

- Wash hands and forearms before eating, drinking, smoking, using the telephone, taking medication, etc.
- Avoid hand-mouth contact when in contaminated areas.

6.Breaks

Contamination should be avoided by taking rest and meal breaks away from the work area.

7. Training

Workers need to be aware of the risks from lead and should receive instruction in how to use any controls and protective equipment. This should be done before they commence work involving lead. Any training needs to be recorded.

8. Supervise

Controls, protective equipment, and welfare need to be supervised to ensure that they remain effective and are used correctly by the workers.

9. Maintain

Employers should ensure that there is enough water, plastic sheeting, clothing, etc. and that equipment is properly maintained.

10. Monitor

Appropriate medical surveillance is needed if workers have significant exposure. This will be covered by the occupational health department or an external company.

Health surveillance for those workers who regularly undertake work where asbestos, or lead are likely to be present

Asbestos

Article 21 of ILO C162 - Asbestos Convention, 1986 (No. 162) requires:

“Workers who are or have been exposed to asbestos shall be provided, in accordance with national law and practice, with such medical examinations as are necessary to supervise their health in relation to the occupational hazard, and to diagnose occupational diseases caused by exposure to asbestos”.

ILO R172 - Asbestos Recommendation, 1986 goes on to state:

“For the prevention of disease and functional impairment related to exposure to asbestos, all workers assigned to work involving exposure to asbestos should be provided, as appropriate, with-

a) a pre-assignment medical examination.
b) periodic medical examinations at appropriate intervals.
c) other tests and investigations, in particular chest radiographs and lung function tests, which may be necessary to supervise their state of health in relation to the occupational hazard and to identify early indicators of disease caused by asbestos.”

Lead

ILO R177 - Chemicals Recommendation, 1990 states:

"The employer, or the institution competent under national law and practice, should be required to arrange, through a method which accords with national law and practice, such medical surveillance of workers as is necessary:

a) for the assessment of the health of workers in relation to hazards caused by exposure to chemicals.
b) for the diagnosis of work-related diseases and injuries caused by exposure to hazardous chemicals.
c) Where the results of medical tests or investigations reveal clinical or preclinical effects, measures should be taken to prevent or reduce exposure of the workers concerned, and to prevent further deterioration of their health.
d) The results of medical examinations should be used to determine health status with respect to exposure to chemicals and should not be used to discriminate against the worker".

Biological monitoring is a tool that is usually used for assessing workers' uptake of lead. It helps to determine whether exposure to lead is adequately controlled.

For biological monitoring of exposure to inorganic lead, measurement of blood lead concentration is used.

Biological monitoring for exposure to organic lead is undertaken by measuring total lead in urine, which reflects exposure to both organic and inorganic lead.

An initial medical assessment should be carried out before a person starts work with lead. This will include determination of a "baseline" blood lead level. Periodic medical assessments should be then carried out. (the UK HSE recommends at intervals of not more than 12 months).

9.8: Ventilation and PPE

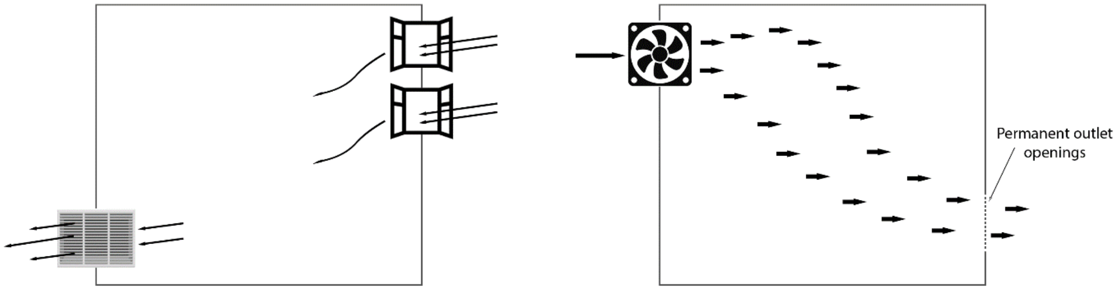
Ventilation

The uses and limitations of dilution ventilation

Dilution' ventilation is a term used to define the flow of air into and out of a working area, for example an office or workshop space, so that any contaminants are diluted by adding some fresh air. This can be provided by either.

- Natural ventilation which relies on wind pressure and temperature differences to move fresh air through a building and is usually not fully controllable.
- Forced or mechanical ventilation which uses mechanical supply and/or extraction to provide fresh air and is controllable.

General or Dilution Ventilation



Natural Ventilation

Mechanical Ventilation

Principles of Operation and Design of Dilution Ventilation

For natural dilution ventilation, the air input can be passive, provided by.

- Naturally occurring air movements
- Open vents
- Windows
- Open doors

For mechanical dilution ventilation, the air input is active, provided by a fan or an air mover. Clean air is moved into the workplace, and this mixes with the contaminated air, diluting the concentration of the hazardous substance.

The position of the air inlets and outlets is determined by the molecular weight of the contaminant. If the contaminant has a tendency to sink, then the air inlets will be positioned at a high level, and the outlets at a low level. If the contaminant rises, then the inlets will be positioned at floor level, and the outlets close to ceiling level.

It is also important that the air flow does not force the contaminants to pass close to workers' breathing zones. The air movement should carry the contaminated air away from the workers. Positioning the inlets and outlets correctly is also important to prevent dead spots where the contaminant can accumulate.

Dilution ventilation will completely replace all the air in a room. This is called an air-change. The risk assessment must calculate how many air changes an hour are necessary to reduce exposure to the substance below its Occupational Exposure Limit.

At the exam, you could be asked to calculate the number of air changes an hour, provided by a dilution ventilation system. The formula for this is:

Volume of air throughput each hour

Volume of the work area.

For example:

- Volume of a room: 20m length, 5m wide, and 3m high.
- Air throughput each hour: 3000m3.

The volume of the room is Length x Width x Height. In this case, 20 x 5 x 3 = 300m3. We can now calculate the number of air changes:

3000 = 10 air changes an hour. (should be 3000 over 300 = 10 air changes an hour)

300

It is preferable to provide dilution ventilation that changes the air more frequently than required. This is because:

- If the dilution ventilation only meets the minimum requirement, there could be some areas of the work area where sufficient dilution does not occur.
- Fans and air movers lose efficiency over time, and the number of air changes will slowly decrease as the equipment wears out. It could decrease below the minimum required air changes.

Dilution ventilation is suitable when the hazardous substances being diluted:

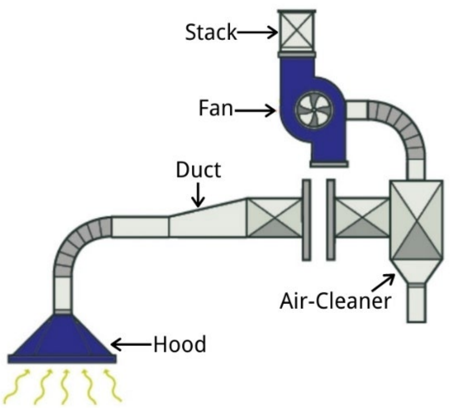
- Have low toxicity, or a high Occupational Exposure Limit.
- Are generated in small quantities, or have a low evaporation rate.
- Are fumes, vapours, or gases. Dilution ventilation is not suitable for dusts, since these tend to settle.
- Are being generated at a steady, uniform, rate.
- Are not being generated close to the workers' breathing zone.

Limitations of dilution ventilation can include:

- The rate of contaminant produced is too high for it to be effectively diluted by the airflow rate.
- The contaminant has a high toxicity.
- The contaminant is not produced at a uniform rate, i.e. there are times where a higher quantity of the contaminant is being generated.
- The contaminant is generated in high concentrations and cannot be reduced below the Occupational Exposure Level.
- The contaminant air may be drawn or blown towards the faces of the workers.
- The air flow may affect the performance of other extraction systems e.g. fume cupboards or LEV.
- The contaminant is a dust, therefore the capture velocity is too low to capture and remove the dust.

The purpose of the typical components of an LEV and their function.

LEV is an engineering control system to reduce exposures to airborne contaminants such as dust, mist, fume, vapour, or gas in a workplace.



Most systems, but not all, have the following:

- **Hood:** This is where the contaminant cloud enters the LEV.
- **Ducting:** This conducts air and the contaminant from the hood to the discharge point.
- **Air cleaner or arrestor:** This filters or cleans the extracted air. Not all systems need air cleaning.
- **Air mover:** The 'engine' that powers the extraction system, usually a fan.
- **Discharge:** This releases the extracted air to a safe place.

Portable LEV

The Hood

Successful LEV systems contain, capture, or receive the contaminant cloud within the LEV hood and carry it away. The greater the degree of enclosure of the source, the more likely it is that control will be successful. Good practice requires monitoring the performance of the hood, for example, by using an airflow indicator.

Hood selection and design are critical to the performance of an LEV system, and must match the process, the source, production and how the operator carries out the process.

LEV systems work effectively when the airborne contaminant cloud is contained, received, or captured by the hood.

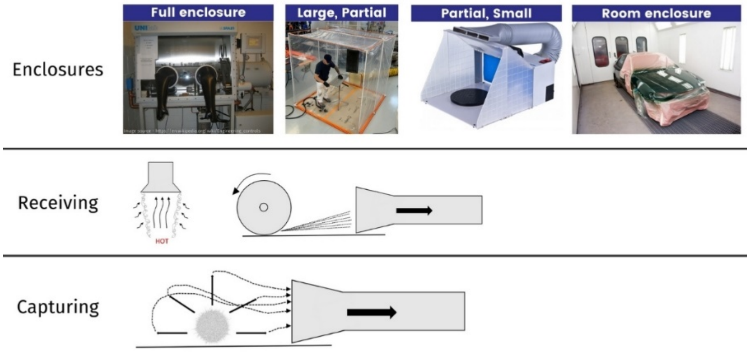
The effectiveness of LEV can be judged by:

- How much the hood constrains the contaminant cloud.
- How well the LEV-induced airflow carries the contaminant cloud into the system.
- How little of the contaminant cloud enters the process operator's breathing zone.

Hoods have a wide range of shapes, sizes, and designs. While they may look similar, they control contaminant clouds in three different ways. The 'classification' of hoods highlights their essential features, and they fall into three basic categories:

- Enclosing hoods
- Receiving hoods
- Capturing hoods

Video - https://www.youtube.com/watch?v=Ky8y2jDk6i8&t=88s



Enclosing Hood

Enclosures are always more effective than capturing or receiving hoods.

- A full enclosure is where the process is completely enclosed, e.g. a glove box.
- A room enclosure or enclosing room is where the operator and the process are enclosed, e.g. abrasive-blasting rooms or paint-spraying cabins. They may also be called laminar flow rooms or booths.
- A partial enclosure contains the process with openings for material and/or operator access, e.g. walk-in booths, and fume cupboards.

Receiving Hood

The process usually takes place outside the hood. The hood receives the contaminant cloud, which has a speed and direction that is usually process generated. Hoods can be fixed or moveable. A canopy hood over a hot process is a classic receiving hood. A push-pull system is a special type of receiving hood.

Captor Hood

This is the most common type of LEV hood and is sometimes called a captor or capture hood. The process, source and contaminant cloud are outside the hood. A capturing hood must generate sufficient airflow at and around the source to 'capture' and draw in the contaminant-laden air. They all work on the same broad principles but can range in size from a few millimetres for on-tool extraction to metres long in large industrial processes. Hoods can be fixed or moveable. They include rim/lip extraction (slot), downdraught tables or benches and LVHV (low volume high velocity) hoods.

Figure 11 - Enclosing hood

Figure 12 - Receiving hood

Figure 13 - Capturing hood

Image source - https://www.hse.gov.uk/pubns/priced/hsg258.pdf

Ductwork

Ductwork connects the components of a ventilation system and conveys the contaminated air from the LEV hood to the discharge point. It consists of some or all the following:

- Ducting from the hood.
- Dampers to adjust or balance the flow in different branches of the LEV system.
- Bends, junctions, and changes in the duct diameter.
- Markings, including test points and hazard warnings of the duct contents.
- A connection to the air cleaner and air mover.
- Access panels for cleaning and inspection.

Usually all the above are under negative pressure (i.e. lower than that in the workplace). Ducting on the discharge side of the air mover will be under positive pressure (i.e. higher than that in the workplace).

Ducts can be either circular or rectangular in cross-section. Circular ducts are generally preferable because they:

- Have a lighter structure for a given cross-sectional area.
- Have a greater ability to withstand pressure differences.
- Produce less noise, as there are no flat panels to act as secondary sources of vibration.

Designers should take the following points into account with regards ductwork:

- Keep the design as simple as possible.
- Provide smooth-bore ductwork and an obstruction-free interior for particle extraction.
- Have a sufficiently high air velocity to keep particles suspended in the air stream, while low enough to keep noise levels acceptable.
- Route ductwork to minimise noise nuisance.
- Keep duct pressures negative within the building, as far as possible.
- Have the minimum number of bends and junctions to minimise the flow resistance.
- When changes of direction are necessary, they should be made smoothly. Junctions and changes of section should also be smooth. Do not use T-junctions.
- Incorporate tapered sections when the duct cross-section needs to change.
- Provide drainage points at any low points in an LEV system for aerosols, mists, or substances that may condense or support combustion.
- Provide access points as appropriate for cleaning and to clear blockages.
- Minimise the length of horizontal run for transport of particles.
- Depending on the expected range of temperatures, the ducting should accommodate thermal expansion and contraction.

Designers need to avoid:

- Long lengths of flexible ducting, which have high flow resistance and low resilience. Flexible ducts can wear, split and are easily damaged.
- Sharp bends, as they cause particles to accumulate and block the duct.

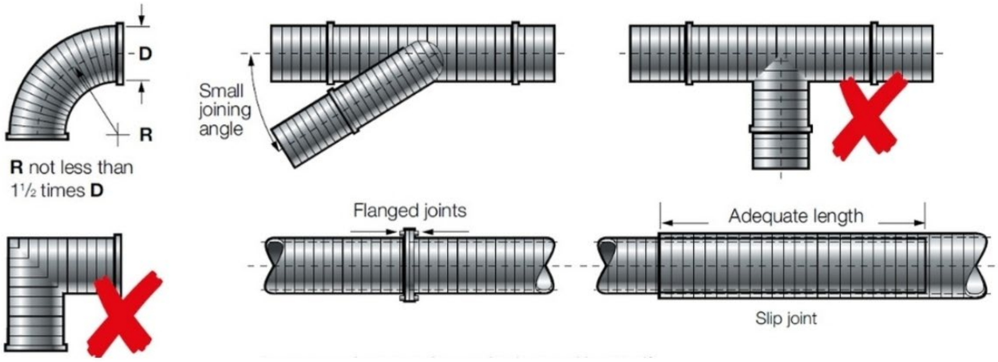


Image source - https://www.hse.gov.uk/pUbns/priced/hsg258.pdf

Fans and Other Air Movers

The fan is the most common air mover. It draws air and contaminant from the hood, through ductwork to discharge. There are five general categories of fan:

- Propeller
- Axial
- Centrifugal
- Turbo exhauster
- Compressed-air-driven air mover

Propeller fans: are often used for general or dilution ventilation. They are light and inexpensive to buy and run, with a wide range of volume flow rates. However, they will not produce much pressure and operate best against low resistance.

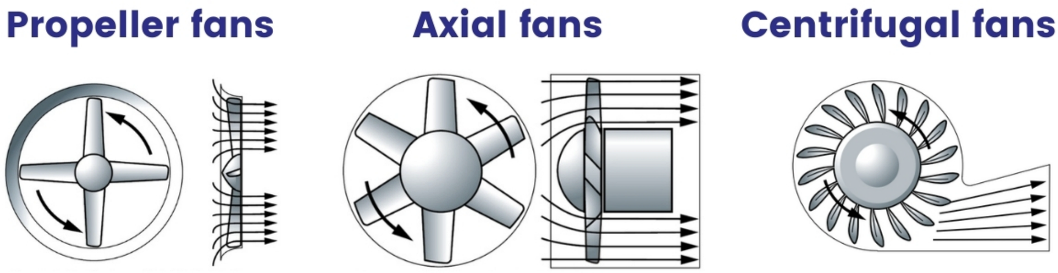


Image source - https://www.hse.gov.uk/pUbns/priced/hsg258.pdf

Axial fans: are not suitable for dusts. They are compact, do not develop high pressures and cannot overcome the resistance to flow that many industrial applications require.

Centrifugal fans: are the most commonly used fans for LEV systems. They generate large differences in pressure and can produce airflows against considerable resistance.

Fan Position

The objective is to have as much of the ductwork as possible under negative pressure. Indoor ductwork upstream of an air mover should normally be under negative pressure. Leakage in this ductwork will then be inward and

contaminated air should not escape into the workplace. One solution is to locate fans and positively pressurised ductwork outside occupied area

Air Cleaners

Air Cleaners for Particles:

Particle collectors are the most common group of air cleaning devices associated with LEV systems. The group consists of fabric filters, cyclones, electrostatic precipitators, and scrubbers.

Fabric filters: These are suitable for dry dusts. Dusty air passes one way through a fabric layer that is flexible and porous. The fabric may be constructed and treated to carry electrostatic forces which help attract and retain dust. Particles are removed by:

- Impaction, where particles, larger than the weave, meet the surface of the filter.
- Impingement, where medium-size particles meet the fibres within the filter weave.
- Diffusion, where small particles are attracted towards the fibres.

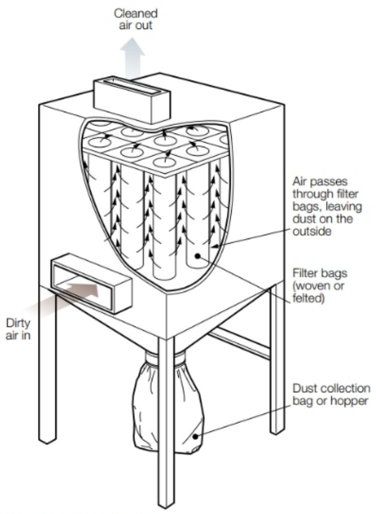


Figure 36 Bag filter unit

Image source - https://www.hse.gov.uk/pUbns/priced/hsg258.pdf

Cyclone filters: consist of a circular chamber, tapered at the bottom. Dusty air feeds at a tangent into the top of the cyclone and swirls around the chamber. This throws particles out to the wall by centrifugal action. The particles' velocities decrease and they fall to a collection hopper at the base of the cyclone. Cleaned air passes through a central outlet in the top of the cyclone. The larger the particle, the easier it is for a cyclone to remove it from the air.

Electrostatic precipitators: are suitable for fine dusts, but unsuitable for heavy contamination. They give dust and fume particles an electrical charge and attract them onto collecting surfaces with an opposite charge. Cleaned air flows out of the device. There are two classes of design:

- Pipe or tube, where a high-voltage wire lies along the axis of a grounded tube.
- Parallel plate, where a series of high-voltage wires lie between a series of grounded metal plates.

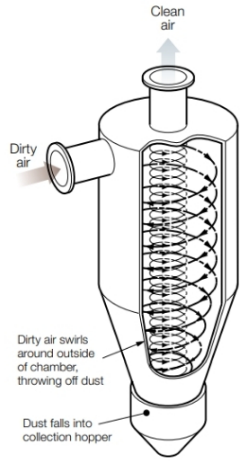


Figure 37 Cyclone dust separator

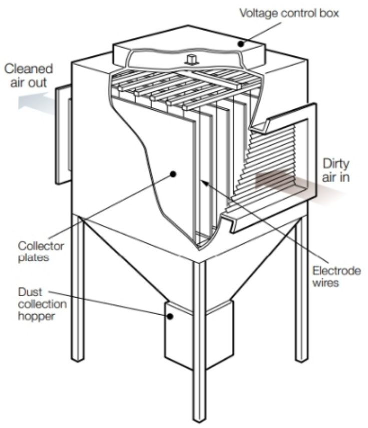


Figure 38 Electrostatic precipitator

Image source - https://www.hse.gov.uk/pUbns/priced/hsg258.pdf

Scrubbers: 'Scrubbing' means wetting particles and washing them out of a contaminant cloud. The design requirements are to:

- Wet the particles.
- Cause them to settle out in water.
- Provide a suitable disposal system.
- Prevent dust building up at the inlet.
- Prevent water carry-over in cleaned air.

There are numerous designs of scrubbers, the most common being venturi scrubbers, self-induced spray collectors, and wet cyclone scrubbers.

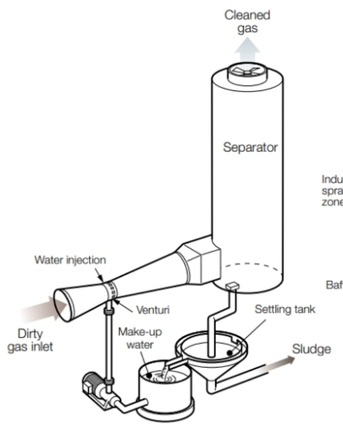


Figure 39 Venturi scrubber

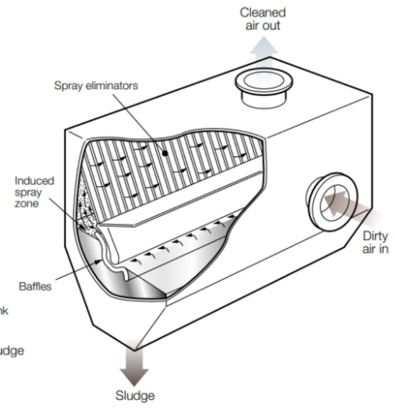


Figure 40 Self-induced spray collector

Image source - https://www.hse.gov.uk/pUbns/priced/hsg258.pdf

Venturi scrubbers: Dusty air passes through a narrow venturi throat which has water injection. The conditions in the throat are highly turbulent. The water separates into small droplets that collide with the dust particles. A cyclone separates the droplets to produce a sludge containing the dust. Cleaned air passes through a central outlet in the top of the cyclone.

Air Cleaners for Gases and Vapours

Destruction methods, such as thermal oxidation (incineration) or flare: Gases or vapour are destroyed before discharge by burning or thermal oxidation. Thermal oxidiser units can be fitted with heat recovery that partially offsets the fuel costs.

Packed tower scrubbers for substances that mix with water: A tower is filled with packing to provide a large surface area. Water or a reagent solution flows in at the top of the tower and contaminated air enters at the bottom. Trickling fluid absorbs the contaminant and cleaned air emerges at the top. To avoid bacterial infection and consequent bad odours, tower scrubbers need regular cleaning. There may be a legionella risk.

Recovery methods, such as absorption: Contaminated air passes through filters that remove gases and vapours. Activated carbon filters are the most common. Air is usually filtered of particles before being passed through a carbon filter. Regeneration of carbon filters and solvent recovery is feasible, but recovery becomes viable only when the solvent usage is high. Impregnated carbons are able to absorb specific chemicals. Typical disadvantages include:

- A frequent need to change the filter.
- The filter fails suddenly when saturated.
- Carbon can develop 'hot spots' that need detectors and fire-extinguishing systems.

Discharge to Atmosphere

Whether or not it has been cleaned, extracted air must not re-enter the building or enter other buildings unless the contaminant has reached negligible concentrations. Discharged air must leave the discharge duct at a high enough speed to make sure it is dispersed. Discharge is normally via a 'stack' (a sort of chimney).

Stack Siting: Buildings have a surrounding 'boundary layer' of air. The objective is to discharge air beyond the boundary layer, and prevent it entering recirculation eddies. The discharge point should be located well above the highest point of a building. The designer needs to know the airflow patterns around a new installation's building, i.e.:

- The recirculation eddy produced by the leading edge of the roof.
- The downwind wake.
- The effect of wind direction.

Stack Design: Gas leaves a discharge stack and rises due to its momentum and buoyancy. Once its energy has decayed and the air cooled to ambient temperature, the plume is carried by the prevailing wind.

Increases in the velocity of the final discharge can be achieved by putting a tapered nozzle on the outlet. Taller stacks prevent the mixing of discharged air with the boundary layer air.

Other ways of increasing the plume velocity are:

- Grouping exhausts into fewer stacks.
- Placing exhausts very close together so that plumes merge.

Source Strength and Capture Zones

The strength of the source is described in terms of the area from which contaminant arises, the flow of contaminant away from the source and the concentration of contaminant within the cloud. The stringency of the control requirement is determined by a combination of the:

- Source strength.

- Cloud volume, shape and speed and its direction of movement.
- Contaminant concentration.

The further a contaminant moves away from its source, the larger the cloud grows through mixing and diffusion. Dilution reduces the concentration of the contaminant in the cloud. But it is always more effective to apply control close to the source of an airborne release because:

- The cloud volume is smaller, so it is easier to control.
- Full interception of the whole cloud is more likely.
- The contaminant is less likely to enter the operator's breathing zone.

Image source - https://www.hse.gov.uk/pUbns/priced/hsg258.pdf

The degree of containment around the emission point is crucial. The hood should be structured and placed at the emission point to entrain and contain the emission. For example, the air-flow rate to a circular extraction duct with no hood attached will fall to about 10% of the in-duct flow rate at one diameter distance from the duct opening. As the distance of the emission point from the hood increases, the LEV effectiveness decreases dramatically.

Thorough Examination of LEV

Routine checks (daily, weekly, and monthly) keep the LEV system running properly. The frequency of routine checks and their description should be set out in the system logbook. A trained worker can make routine checks. Workers should report any defects in LEV to their supervisor. The employer must ensure that those who check or examine LEV have adequate knowledge, training, and expertise, i.e. they are competent.

Thorough Examination and Testing

A thorough examination and test is a detailed and systematic examination sufficient to ensure that the LEV can continue to perform as intended by design and will contribute to the adequate control of exposure. The thorough examination would normally include such functional testing to provide sufficient evidence to indicate adequate control is being achieved. The thorough examination and test may be carried out by a person who is competent and can make an objective assessment of the LEV. This can be:

- An outside contractor.
- A competent worker of the LEV owner (the employer).

Frequency of Thorough Examination and Testing

The maximum time between tests of LEV systems often set down in national law (for example in the UK, under the COSHH regulations, this is 14 months. In practice, this is normally done annually). If wear and tear on the LEV system makes it likely system effectiveness will degrade between tests, then thorough examinations and tests should be more frequent.

Preparing to Check, Maintain, Repair and Examine LEV

The LEV examiner needs to know the risks from the system under test. These include:

- Health risks from residues within the systems.
- Safety risks from mechanical parts of the LEV, work at height, electricity, manual handling and moving vehicles.

The employer and examiner need to cooperate to ensure minimal risk for both service provider and workers (operators) who may be affected by the work. The employer should arrange for permits-to-work (where necessary) and safe access. The employer should also provide information about personal protective equipment requirements.

For legally required thorough examination and testing, the examiner should, where available, use the following information sources:

- The LEV system commissioning report.
- The LEV user manual.
- The logbook for the system.
- The previous LEV system statutory report.
- Confirmation that there have been no changes to the LEV, layout, or process since the last test.

The examiner should verify that the documents apply to the system under test. If none of these documents is available, an adequate 'thorough examination and test' could take the status of a commissioning report. In such cases, the examiner's report would need to contain sufficient detail to produce information for a user manual.

Carrying out a Thorough Examination and Test

The examination and test procedure and methods are similar to the original commissioning exercise, with similar qualitative and quantitative methods. Thorough examination and testing of LEV can be considered to comprise three stages:

Stage 1: A thorough visual examination to verify the LEV is in efficient working order, in good repair, and in a clean condition.

Stage 2: Measuring and examining the technical performance to check conformity with commissioning or other sources of relevant information.

Stage 3: Assessment to check the control of worker exposure is adequate.

LEV examiners need the appropriate equipment such as "Pitot tubes", a smoke generator, a dust lamp, an anemometer and, sometimes, equipment for air sampling.

Stage 1: Thorough Visual and Structural Examination

This may include, as appropriate:

- Thorough external examination of all parts of the system for damage, wear, and tear.
- Internal duct examinations.
- Checks that any filter cleaning devices (e.g. shake-down, reverse, or pulsed jet) work correctly.
- Inspection of the filter fabric. Where filters have built-in pressure gauges, checks on their function (and that the operating pressure is correct).
- Checks of the water flow and sump condition in a wet scrubber.
- Checks that the monitors and alerts or alarms are functioning correctly.
- Inspection of the air mover drive mechanism, e.g. fan belt.
- Checks for indications of effectiveness. Are there significant deposits of settled dust in and around the LEV hood? Is any part of the system vibrating or noisy?

Stage 2: Measure Technical Performance

This may include, as appropriate:

- Test points (e.g. indicated in the system documentation). This includes hood faces, branch ducts and the main duct.
- Measuring static pressure at suitable test points indicated in the system documentation. This includes all hoods, ducting, across the air cleaner and fan.
- Checking the fan speed, motor speed and electrical power consumption.
- Check direction of rotation of the fan impeller.
- Checking the replacement or make-up air supply.
- Testing alarms, by simulating a failure, and the alarm's ability to detect the failure.
- Measuring air temperatures.
- Testing the air cleaner performance (e.g., a re-circulating system).

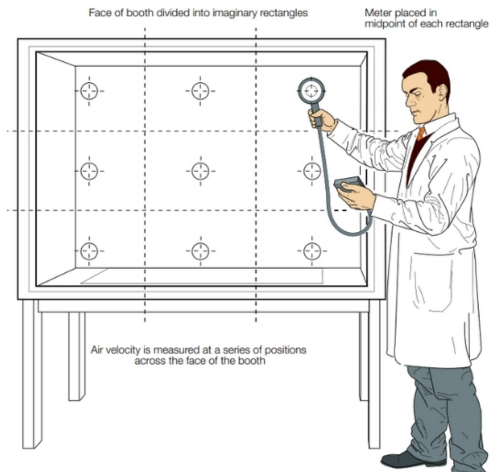


Figure 48 Testing large hood face velocities

Image source - https://www.hse.gov.uk/pUbns/priced/hsg258.pdf

Stage 3: Assess Control Effectiveness

This may include, as appropriate:

- Careful observation of processes and sources.
- Assessment of how effective the LEV is at controlling operators' exposure.
- Challenge tests with smoke with the process running, to check for smoke leakage, eddying and breathing zone encroachment (when smoke testing, the examiner should warn workers and may need smoke alarms turned off).
- Dust lamp tests with the process running to check for the escape of dust or mist.
- Observation of the way operators work, whether the LEV is providing adequate control and protecting the operators from any contaminants.

Report of LEV Thorough Examination and Test

A comprehensive report will include:

- The name and address of the employer responsible for the LEV.
- The date of examination and test.
- The date of the last thorough examination and test.
- The identification and location of the LEV, and the process and hazardous substance concerned.
- The conditions at the time of the test and whether this was normal production or special conditions.
- A simple diagram of the LEV layout and location, with test points.
- The condition of the LEV system including hood serial numbers and, where appropriate, photographs of relevant parts.
- Its intended operating performance for adequately controlling the hazardous substance and whether it is still achieving the same performance.
- The methods used to make a judgement of performance and what needs to be done to achieve that performance, e.g. visual, pressure measurements, airflow measurements, dust lamp, air sampling, tests to check the condition and effectiveness of the filter.
- The results of any air sampling relevant to LEV performance.
- Comments on the way operators used the LEV.
- Comments on system wear and tear and whether components may need repair or replacement before the next annual test.
- The name, job title and employer of the person carrying out the examination and test.
- The signature of the person carrying out the examination and test.
- The details of any minor adjustments or repairs carried out to make the LEV system effective.

Interpretation of the test results and subsequent recommendations concerning LEV equipment rely on the qualified expertise and practical experience of the LEV examiner.

Critical defects should be reported immediately and before the report is produced in order to avoid any delay in rectifying safety critical equipment.

Potential Problems with LEV Systems

Disadvantages of LEV:

- If the LEV is incorrectly placed, contaminants can be drawn into The operators' breathing zone or the process
- Emissions drawn into the system must be disposed of safely and without adverse effects on the environment.

- It is an additional system to operate and maintain, otherwise it could become an exposure and/or fire hazard.
- Workers must be properly trained in the system's correct use, its effectiveness and maintenance needs.
- LEV can supply oxygen to a fire. For this reason, it is often necessary to link it to the fire alarm and detection system so it turns off automatically if the fire alarm is activated.

Issues that might Make LEV Inefficient.

- Poorly designed system (such as under sizing the extraction fan).
- Playing the captor hood too far away from the contaminant (such as a welding fume captor hood).
- Change in operation (such as using a system that was designed for vapours, to extract metal fume).
- Making unauthorised changes to the system (such as adding "branch" ducting to the system).
- Blockages in the filtration system (possibly by failure to empty or clean).
- Leaks from the ducting.

PPE/RPE

The types of PPE for use with hazardous substances (chemical and biological)

Chemicals can cause harm to humans in several different ways. They can cause injury through direct skin contact, by inhalation of gases, fumes, vapours, and dusts, and by inadvertent ingestion. The following lists the PPE available to protect the different parts of the body.

- Eye and face protection, including safety glasses, goggles, face-shields, and visors.
- Hand and arm protection, mainly gloves and gauntlets.
- Foot protection, such as boots and wellingtons.
- Respiratory protection, such as masks, respirators, and breathing apparatus.

Respiratory protective equipment (RPE)

Many workers wear respirators or breathing apparatus to protect their health in the workplace. These devices are collectively known as respiratory protective equipment (RPE). Respirators filter the air to remove harmful substances and breathing apparatus (BA) provides clean air for the worker to breathe.

Work activities may result in harmful substances contaminating the air in the form of dust, mist, vapour, gas, or fume. For example, when:

- Cutting a material such as stone or wood
- Using a product containing volatile solvents
- Handling a dusty powder
- Welding stainless steel, generating welding fumes

Workers may also need to work in areas where oxygen levels are or may become low, for example: confined spaces, such as a trench, silo, or tank.

RPE is a particular type of personal protective equipment (PPE) designed to protect the wearer from breathing in harmful substances or from oxygen-deficient atmospheres when other controls are either not possible or insufficient on their own.

In the following sections we will discuss:

- The types of respirators and breathing apparatus, and their applications and limitations.
- The selection criteria for RPE, including:
    - Atmosphere or substance related issues.
    - Task and work area related issues.
    - Wearer related issues.
    - Quality related issues.
- Face fit testing.

The Types of RPE and their Application and Limitations

There are basically two categories of respiratory protection:

- **Respirators:** Filter contaminants from contaminated air (such as dust, solvent vapour).
- **Breathing Apparatus:** Provided a clean supply of oxygen (such as going into confined spaces which are oxygen depleted).

Respirators must NEVER be used in oxygen depleted atmospheres. They do not provide oxygen.

Whichever RPE is used it must be adequate, in that it reduces exposure to the level required to protect the wearer's health. It must also be suitable, in that it is right for the wearer, task, and environment, such that the wearer can work freely and without additional risks due to the RPE.

Respirators

Types include:

- Disposable half mask.
- Re-usable half mask.
- Full face mask.
- Powered mask.
- Powered hood, helmet.

A non-powered respirator relies on the wearer's breathing to draw air through the filter.

A powered respirator will use a motor to pass air through the filter to give a supply of clean air. This makes breathing easier but requires a power supply.

The correct type of respirator filter must be used as each is effective for only a limited range of substances. Where there is a shortage of oxygen or any danger of losing consciousness due to exposure to high levels of harmful fumes, only use breathing apparatus - never use a filtering cartridge. Filters only have a limited life; when replacing them or any other part, check with the manufacturer's guidance and ensure the correct replacement part is used.

The filter is a key component of any respirator. Filters are available for solid or liquid particles, vapours, and gases. They can be an intrinsic part of the device or come separately so they can be changed on a reusable respirator. It is vital that you choose the correct filter, which will be effective against the hazard.

There are two basic filter types available:

- Particle filters.
- Gas or vapour filters.

Airborne liquids like fine sprays and mists, and solid materials like dusts, fibres, smoke, and fume, require a particle filter.

Neither type of filter can be used in an oxygen deficient atmosphere. Some situations may require a combination of filters to protect against the different substances or forms present.

Breathing Apparatus

There are different types but all:

- Will supply air from an independent source such as a compressed air cylinder or air compressor.
- Can be used against a range of airborne hazards and in different atmospheres.

Breathing apparatus (BA) comprise a mask, an airline, and a supply. The self-contained BA is fed from a cylinder worn on the back of a user. In this situation, there is a limited air supply (usually about 30 minutes).

The compressor fed type has a similar mask and supply line. However, it has a compressor to supply air, which means it can be used for unlimited periods. The disadvantage is the limitations on movement caused by the airline.

Breathing apparatus is used when there are high levels of toxic material (such as smoke in a building; hydrogen sulphide leak at a chemical plant; methane in a sewer) or when there may be depleted oxygen (such as in some confined space entry activities).

Atmosphere or Substance Related Factors

RPE can protect against two different types of hazards:

- Hazardous substances in the atmosphere, which could be inhaled.
- Oxygen deficiency.

These two hazards are entirely different. Respirators filter out certain types of hazardous substances. Breathing apparatus provides fresh air to the wearer.

The choice between the two depends on whether an oxygen deficiency is likely to be present or not.

Assigned Protection Factor (APF)

You need to ensure that the RPE you select can protect the worker from the hazardous substance in the air around them. Your decision will depend on the amount in the air and its form (e.g. particles, vapour). There are various types of respirator and BA available. The protection they offer will be determined by several things, including the protection factor. In simple terms, this is the ratio of hazardous substance outside the RPE to the amount inside the RPE.

To help you, each RPE type and class is categorised by an assigned protection factor (APF). The APF is a number rating that indicates how much protection that type of RPE can provide. For example, RPE with an APF of 10 will reduce the wearer's exposure by at least a factor of 10 if used properly, or, to put it another way, the wearer will only breathe in one-tenth or less of the amount of substance present in the air.

There are only a few number ratings used, so RPE APFs will be either: 4; 10; 20; 40; 200; or 2000. When calculating the protection factor, always choose an APF above the calculated value.

When choosing an RPE device with an APF capable of providing the wearer with adequate protection, check the following:

- Does the safety data sheet (SDS) provide advice on the required APF?
- Does the substance have a prescribed workplace or occupational exposure limit (OEL)? If so, you need to make sure the wearer is protected to a level below the OEL.

If there is no advice on the required APF in the SDS, you can calculate the required protection factor using the OEL and the quantity of the substance in the air. Find out the amount of substance in the air by taking exposure measurements in your workplace.

Task and Work Area Related Factors

Suitability factors:

In addition to making sure the RPE you use is adequate to control the hazards, you need to ensure it is suitable for:

- The individual wearer
- The tasks they are doing
- The environment in which they are working

Work rate: Higher work rates may increase breathing and sweating, which can affect the performance of some types of RPE. Higher breathing rates can cause contaminants to leak in, and sweating can cause face pieces to slip and leak.

Duration: Unpowered tight-fitting masks become uncomfortable to wear for long periods and wearers may be tempted to loosen or remove the RPE. For work periods of more than 1 hour, powered RPE will help minimise fatigue and discomfort.

Abnormal temperature or humidity: In hot and humid conditions, wearing RPE increases heat stress, sweating and discomfort. RPE can be heavy, and can require more laborious breathing which increases body temperature through physical exertion. Cooling provided by powered respirators or air fed BA helps minimise this problem.

Criticality of Clear Vision: If you need to see fine details when wearing RPE, but don't need to protect the eyes from the airborne hazard, RPE types which include face protection (full face masks, visors, hoods) may not be ideal because they can be prone to scratching, misting and surface contamination.

Communications, Mobility, and Space Constraints: All RPE affects your ability to communicate. The human voice will be muffled by the mask, and possibly the noise of powered respirators. Many types of RPE also cover the ears, making hearing and understanding speech more difficult. RPE incorporating proprietary communication devices (ranging from simple speech diaphragms to complex radio intercom systems) can be purchased if needed.

The bulkiness and weight of certain types of RPE, such as self-contained breathing apparatus, can make movement slow and awkward. Self-contained air cylinders take up a large space directly on the wearer's back. Air lines from compressors can trail long distances and get caught or stuck on equipment or on the corners of walls, restricting movement. It can be particularly difficult to access confined spaces which can require climbing into small manholes or entering vessels through narrow access points. The difficulties in access and egress must be taken into account during the risk assessment.

Use of air power tools: Connecting air-powered tools and your RPE to the same air supply will affect RPE performance. Ensure that your compressor can supply enough air for both at the same time.

Flammable or explosive atmospheres: RPE can be a source of ignition. If you cannot avoid working in potentially flammable or explosive atmospheres, you may need to use intrinsically safe, light alloy-free, and antistatic RPE.

Comfort and Compatibility of RPE

Employers should take the fit and comfort of RPE into consideration when selecting appropriate items for their workplace. RPE that fits well and is comfortable to wear is more likely to be worn when needed and to be worn correctly. Most protective devices are available in multiple sizes and care should be taken to select the proper size for each worker. Involving workers in the selection of PPE will further ensure that it will be comfortable and worn. If several different types of PPE are worn together, make sure they are compatible. The different types of eye, hearing, or respiratory protection worn must not interfere with each other. For example, a face mask could break the seal of earmuffs around the ear.

Facial hair and markings: Any facial hair can potentially break the seal of a mask, allowing contaminated air to enter, increasing exposure. Workers who wear RPE must be clean shaven, or have their facial hair trimmed to a shape which does not interfere with the seal.

For those countries where facial hair is a cultural or religious requirement, this can be a significant barrier to wearing the RPE. However, the key is consultation and communication. The employer must be extremely clear to the workers that wearing the RPE correctly is a mandatory condition of employment and is necessary for their health or survival. Secondly, the workers should be able to trim their beards and facial hair to a satisfactory length and shape to enable them to wear the RPE correctly, whilst respecting their cultural and religious needs.

Spectacles: Spectacles with side arms are incompatible with full face masks as they break the face seal, and they may also interfere with the fit of half masks. RPE manufacturers can provide special frames which fit inside the mask.

Health conditions: RPE can make breathing more laborious, especially non-powered RPE where air must be forced through the filter. RPE, such as breathing apparatus, can also be very heavy. It can require much physical force to carry it around, in addition to the physical exertion of work. Individuals who use RPE must be physically fit. Certain individuals may not be suitable for the use of RPE, especially those who are physically unfit or who have a medical condition such as asthma or a heart condition.

Quality Related Factors

RPE used at work must be manufactured in accordance with any national regulations. In practice, this means you need to ensure your equipment is marked to an appropriate standard. In Europe, this will be a CE mark. The CE mark on RPE tells you that the equipment has met the minimum legal requirements for its design.

CE marking does not indicate that an RPE device is automatically adequate and suitable for use in your workplace. It is your responsibility to select the correct RPE to meet your specific requirements.

Outside of the EU, the CE mark is not required. However, it is necessary to purchase and use RPE which conforms to the relevant international standards. If the RPE does not conform, then it is likely that its protection is unreliable or non-existent.

Disposable Dust Masks: these must conform to EN149 which categorises disposable dust masks into 3 categories.

- FFP1: protects against low levels of dust, as well as solids and liquid aerosols. Provides an APF of 4 when used correctly. Suitable for low-risk activities with minimal dust generation.
- FFP2: protects against moderate levels of dust, solids, and liquid aerosols. Provides an APF of 10 or protects against materials in concentrations of up to 12 times the OEL. Suitable for sanding and plastering.
- FFP3: protects against higher levels of dust, solids, and liquid aerosols. Provides an APF of 20 or suitable for hazardous substance concentrations up to 50 times the OEL. Suitable for handling hazardous powders.

Half Mask Respirators for Particulates: these must conform to EN 140 (mask design) and EN 143 (filter efficiency). The continuous wear time should be limited to less than one hour. There are three categories of particle filter:

- Half mask + P1 filter: APF 4
- Half mask + P2 filter: APF 10
- Half mask + P3 filter: APF 20

Half Mask Respirator for Gases and Vapours: these must conform to EN140 and EN 14387 (filter type). They all provide an APF of 10. The three types of filter protect against different types of gases and vapours.

Full Face Respirator: The filters used on full face respirators are the same as those attached to half masks. However, the full-face respirator must comply with the specifications in EN 136. P1 and P2 filters still provide APFs of 4 and 10, respectively. But a full-face respirator with a P3 filter will provide an APF of 40, which is double that of a half mask.

Face Fit Testing for RPE

Face fit testing is a method of checking that a tight-fitting face piece matches the wearer's facial features and seals adequately to their face. It will also help to identify unsuitable face pieces that should not be used. You should carry out a fit test as part of the initial selection of the RPE. Remember that tight-fitting RPE will only provide effective protection if the wearer is clean shaven, so they should also be clean shaven around the seal when fit tested.

The performance of tight-fitting face pieces depends on achieving a good contact between the Wearer's skin and the face seal of the face piece. People's faces vary significantly in shape and size so it is unlikely that one type or size of RPE face piece will fit everyone. Inadequate fit will significantly reduce the protection provided to the wearer. Any reduction in protection can put the RPE wearer's life in danger or may lead to immediate or long-term ill health.

Fit testing can also serve as a useful training tool for teaching the wearer how to put on their face piece correctly. Correct fitting of the face piece always is vital to prevent exposure.

When considering fit testing give thought to whether the wearer will need to use other PPE to ensure it is compatible and does not interfere with the protection offered by the RPE.

There are two basic types of RPE fit testing: qualitative and quantitative.

Qualitative fit testing

Qualitative fit testing is a pass/fail test based on the wearer's subjective assessment of any leakage from the face seal region, by sensing the introduction of a test agent. These tests are suitable for half masks. They are not suitable for full face masks. Examples of qualitative fit testing methods are:

- Method based on bitter- or sweet-tasting aerosol.
- Method based on odour compounds.

Quantitative fit testing:

Quantitative fit testing provides a numerical measure of the fit, called a fit factor. These tests give an objective measure of face fit. They require specialised equipment and are more complicated to carry out than qualitative methods. Quantitative methods are suitable for full face masks (but can also be used for half masks). Examples of quantitative fit testing methods are:

- Laboratory test chamber.
- Portable fit test devices, such as a particle counting device.

Skin and Eye Protection: Types, Applications, and Limitations

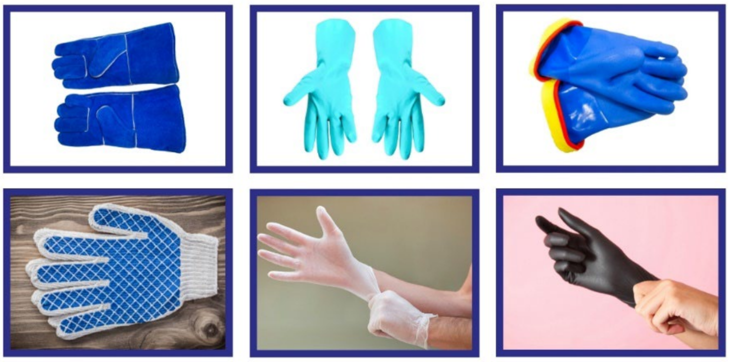
Eyes and Face: protection from chemical or metal splash, dust, projectiles, gas, and vapour offered by:

- Safety spectacles
- Goggles, face screens
- Face-shields
- Visors

The eye protection chosen should have the right combination of impact, dust, splash, molten metal eye protection for the task and fits the user properly. Many chemicals come in the form of dusts, mists, liquids, and aerosols. Therefore it is important for eye protection to provide a full seal around

the eyes. Safety glasses or spectacles only provide against impact and will allow chemicals to contact the eyes through the sides or from the forehead. Therefore, from a chemical protection perspective, goggles and face shields are preferable. However, these do tend to mist up and hinder visibility, so cannot be used in certain environmental conditions or for long periods.

Hands and arms: protection from chemicals provided by a variety of glove types. Chemical-resistant gloves are made with different kinds of rubber (natural, latex, butyl, neoprene, nitrile, and fluorocarbon) or various kinds of plastic (PVC, polyvinyl alcohol). These materials can be blended or laminated for better performance.



As a rule, the thicker the glove material, the greater the chemical resistance. But thick gloves may impair grip and dexterity, having a negative impact on safety (for example, instrument mechanics working on small bore systems need a great deal of dexterity. This should be borne in mind when selecting suitable gloves). Certain gloves have different resistance to different chemicals (for example, latex and rubber is good for exposure to acetone, whereas nitrile is poor). Manufacturers or suppliers will provide details or tables for the best gloves for a particular application.

Gloves can be uncomfortable and make the hands sweat. Whilst sweat is not considered to be a hazardous substance, wearing gloves over sweaty hands for long periods can cause various skin conditions such as rashes and irritation.

Gloves can also deteriorate with exposure to chemicals, UV radiation, and wear and tear. This deterioration is not always obvious. Therefore, they can provide a false sense of security.

Latex gloves can cause an allergic reaction in some individuals as well as conditions such as Asthma and Dermatitis. Therefore wherever possible Latex gloves should be powder free and of a low protein.

Body protection: Materials like those used for gloves are used in chemical resistant body coverings, ranging from general purposes to PVC to thick neoprene.

Footwear: Footwear that provides protection against chemicals come in three basic types.

- Boots (with a vulcanised rubber sole) usually for minimal chemical exposures.
- Wellingtons and over boots (made of rubber compounds) where more significant exposures may be expected.

Like other forms of PPE, when choosing footwear, an appropriate standard should be consulted and conformed with. European EN13832-2: 2006 (Footwear protecting against chemicals) is one such standard.

Chemical Compatibility

The phrase commonly found on the Safety Data Sheet (SDS) "Wear impervious (or impermeable) gloves" has very limited value. It is technically inaccurate. No glove material will remain impervious to a specific chemical forever. No one glove material is resistant to all chemicals. Some chemicals will travel through or permeate the glove in a few seconds, while other chemicals may take days or weeks.

Information specifying the best type of chemical protective material is what should be on the SDS (e.g., neoprene, butyl rubber). If this information is missing, contact the supplier or manufacturer of the product. Manufacturers of chemical protective gloves and clothing may also assist their customers in making the appropriate choices.

In the selection of eye protection, it is important to check that the eye protection will not be damaged, corroded, embrittled, or otherwise degraded by frequent exposure to chemicals.

Level of Protection Required

When considering the level of protection, there are three criteria to consider:

- "Permeation rate" is the rate at which the chemical will move through the material. It is measured in a laboratory and is expressed in units like milligrams per square meter per second (or some other [weight of chemical] per [unit area of material] per [unit of time]). The higher the permeation rate, the faster the chemical will move through the material.
    - Permeation is different from penetration. Penetration occurs when the chemical leaks through seams, pinholes, and other imperfections in the material: permeation occurs when the chemical diffuses or travels through intact material.
- "Breakthrough time" is the time it takes a chemical to permeate completely through the material. It is determined by applying the chemical on the glove exterior and measuring the time it takes to detect the chemical on the inside surface. The sensitivity of the analytical instruments used in these measurements influence when a chemical is first detected. The breakthrough time gives some indication of how long a glove can be used before the chemical will permeate through the material.
- "Degradation" is a measurement of the physical deterioration of the material due to contact with a chemical. The material may get harder, stiffer, more brittle, softer, weaker, or may swell. The worst example is that the material may actually dissolve in the chemical.

Your assessment of the risks from chemical exposure will consider the frequency, duration, and nature of the exposure of the chemical. With that information, you can select a skin protection product which provides the necessary level of protection. For example, if there is only accidental and infrequent splashes of chemicals on the

hands, then a disposable glove with a fast permeation rate might be acceptable. However, if the task requires frequent and lengthy direct contact with the chemical, then a glove with a much longer breakthrough time might be required.

Also consider the length of the gloves. In some cases, gauntlets may be needed to protect the forearms.

Duration

As per the previous page, if the task requires lengthy contact with the chemical, it is preferable to select a glove with a greater breakthrough time. Alternatively, regular changes of gloves will be required.

Choice between Dexterity and Durability

Generally, the thicker the glove, the greater the breakthrough time. As a result, gloves with high breakthrough times can be very thick, bulky, and inflexible. This can greatly reduce the wearer's dexterity and sense of touch, making the job harder. If the gloves make the job harder, workers are less likely to wear the gloves.

It is for this reason that involvement of workers is so important during the glove selection process. A selection of gloves should be chosen and trialled by the workers, prior to making a commitment on the type of glove to be used.

In some cases, dexterity is critical to the completion of the task. Therefore, it may be necessary to provide the workers with thin disposable gloves which need to be changed frequently. However, this can cause several problems:

- The gloves may be worn for too long.
- Removing the gloves requires a special technique to avoid getting the chemicals on the workers' hands.

If workers are forced to wear gloves which limit their dexterity, you might find that they avoid wearing the gloves unless directly supervised. In some cases, they may even sabotage their gloves by cutting off the finger ends.

Gloves versus Gauntlets

As previously mentioned, if the task creates a risk of exposure of the forearms, then gauntlets may be the preferred option.

Wearer Related Factors

Like RPE, there are international and European standards which apply to eye and skin protection. There are standards that related to chemical protection, and other hazards such as mechanical and thermal.

With respect to Europe, for chemical skin protection, the main two standards are EN 420 (related to the general requirements for protective gloves) and EN 374 (protection from chemicals and micro-organisms).

EN 374 categorises gloves in terms of their chemical resistance i.e. permeation rates and breakthrough times.

Eye protection is governed by EN 166, which categorises eye protection according to its resistance to a wide range of hazards, including impacts and radiation. Eye protection is labelled according to the hazards which is it will protect against.

The Storage and Maintenance of PPE

An effective system of maintenance of PPE is essential to make sure the equipment continues to provide the degree of protection for which it is designed. Therefore, the manufacturer's maintenance schedule (including recommended

replacement periods and shelf lives) must always be followed. Inspect PPE before each use. With most PPE, it only takes a few minutes to inspect the equipment for any breaks, tears and visible signs of stress or damage.

Maintenance may include cleaning, examination, replacement, repair, and testing. You may be able to carry out simple maintenance (e.g. cleaning), but more intricate repairs must only be carried out by competent personnel.

Immediately remove any damaged equipment from service until a competent person or a manufacturer's representative can certify the equipment for use.

The costs associated with the maintenance of PPE are the responsibility of the employer.

Where PPE is provided, adequate storage facilities for PPE must be made available for when it is not in use, unless the worker may take PPE away from the workplace (e.g., safety foot wear). All PPE must be stored in a clean and sanitary condition ready for use. Accommodation may be simple, e.g. pegs for waterproof clothing or safety helmets, and it need not be fixed, e.g., a case for safety glasses, a container in a vehicle, or zip-lock bags on a designated shelf. Storage should be adequate to protect the PPE from contamination, loss, damage, water, or sunlight. Proper storage often requires a dry and clean place that is not subject to temperature extremes. A hard hat hanging in the back window of a truck, for example, may suffer sun and heat damage that prematurely ages the shell, reducing worker protection. Where PPE may become contaminated during use, storage should be separate from any storage provided for ordinary clothing.

Training in the Correct use of PPE

Where PPE is provided, workers must be provided with adequate information, instruction and/or training on its use. This should ensure that PPE is worn, and worn correctly, when it is needed.

The extent of information, instruction and/or training will vary with the complexity and performance of the kit. For example, a full Breathing Apparatus kit will require more training to use properly than a disposable face mask.

Information and instruction should cover:

- The risk(s) present and why the PPE is needed.
- The operation (including demonstration), performance and limitations of the equipment.
- Use and storage (including how to put it on, how to adjust and remove it).
- Any testing requirements before use.
- Any user maintenance that can be carried out (e.g. hygiene or cleaning procedures).
- Factors that can affect the performance of the equipment (e.g. working conditions, personal factors, defects, and damage).
- How to recognise defects in PPE, and arrangements for reporting them.
- Where to obtain replacement PPE.

In addition to initial training, refresher training may be required from time to time. Supervisor checks on the use of PPE may help determine when refresher training is required.

9.9: Hazardous substances monitoring

The concept of exposure standards

National regulatory agencies set the limits to which workers can be exposed to hazards. They include limits on noise, vibration, and temperature.

With respect to hazardous substances, international examples of exposure standards include as "Workplace Exposure Limits"(WELs) used in UK and "Threshold Limit Values" (TLVs) used in the US.

Some exposure standards set a firm upper limit for exposures e.g. a peak noise limit, or upper temperature not to be exceeded. Others will consider both the quantity of exposure and the length of time the person is exposed to the hazard.

The Meaning of Exposure Limits for Airborne Harmful Substances

"Exposure standards (or “limits”)" represent the airborne concentration of a particular substance or mixture that should not be exceeded. There are three types of exposure standard:

- 8-hour time-weighted average (considered the long-term exposure limit).
- Peak limitation ("ceiling value").
- Short term exposure limit (often averaged over 15-minute time periods).

Exposure standards are based on the airborne concentrations of individual substances which, according to current knowledge, should not cause adverse health effects nor cause undue discomfort to nearly all workers.

They do not represent a fine dividing line between a healthy and unhealthy work environment. Natural biological variation and the range of individual susceptibilities mean that a small number of people might experience adverse health effects below the exposure standard. Additionally, when considering exposure to hazardous substances other routes of entry to the body need to be considered, such as absorption through the skin, ingestion, or injection.

Note: In addition to airborne limits, exposure standard tables (such as the UK "EH 40" publication) will also indicate where a substance can be absorbed through the skin, or when a substance has sensitising or carcinogenic properties (see table that follows).

Substance	CAS Number	Workplace exposure limit				Comments
		Long-term exposure limit (8-hr TWA reference period)		Short-term exposure limit (15 min reference period)		The Carc, Sen and Sk notations are not exhaustive. Notations have been applied to substances identified in IOELV Directives
		ppm	mg.m³	ppm	mg.m³	
Acetaldehyde	75-07-0	20	37	50	92	
Acetic anhydride	108-24-7	0.5	2.5	2	10	
Acetone	67-64-1	500	1210	1500	3620	
Acetonitrile	75-05-8	40	68	60	102	
o-Acetylsalicylic acid	50-78-2	-	5	-	-	
Acrylaldehyde (Acrolein)	107-02-8	0.1	0.23	0.3	0.7	
Acrylamide	79-06-1	-	0.3	-	-	Carc, Sk
Acrylonitrile	107-13-1	2	4.4	-	-	Carc, Sk
Allyl alcohol	107-18-6	2	4.8	4	9.7	Sk
Aluminium alkyl compounds		-	2	-	-	
Aluminium metal inhalable dust respirable dust	7429-90-5	 - -	 10 4	 - -	 - -	

The Significance of Short Term (STEL) and Long Term (LTEL) Exposure Levels and Time Weighted Averages (TWA)

Effects of exposure to substances hazardous to health vary considerably depending on the nature of the substance and the pattern of exposure. Some effects require prolonged or accumulated exposure.

The long-term (8-hour TWA) exposure limit (LTEL) is intended to control such effects by restricting the total intake by inhalation over one or more work shifts, depending on the length of the shift. Other effects may be seen after brief exposures. Short-term (usually 15 minutes) exposure limits (STEL) may be applied to control these effects. For those substances for which no short-term limit is specified, it is recommended that a figure of three times the long-term limit be used as a guideline for controlling short-term peaks in exposure.

Some workplace activities give rise to frequent short (less than 15 minutes) periods of high exposure which, if averaged over time, do not exceed either an 8-hour TWA or a 15-minute TWA. Such exposures have the potential to cause harm and should be subject to reasonably practicable means of control unless a 'suitable and sufficient' risk assessment shows no risk to health from such exposures.

Both the long-term and short-term exposure limits are expressed as airborne concentrations averaged over a specified period. The period for the long-term limit is normally eight hours when a different period is used this is stated. The averaging period for the short-term exposure limit is normally 15 minutes, such a limit applying to any 15-minute period throughout the working shift.

In workplace exposure limits, concentrations of airborne particles (fume, dust Etc.) are usually expressed in mg.m-3. The limits for fibres (such as man- made mineral fibres, or asbestos) are generally expressed as fibres per millilitre of air (fibres.ml-1).

Workplace exposure limits for volatile substances are usually expressed in both parts per million by volume (ppm) and milligrams per cubic metre (mg.m-3). For these substances, limits are set in ppm, and a conversion to mg.m-3 is calculated.

The value in mg.m-3 for a given concentration in ppm depends on the temperature and pressure of the ambient air, which varies over time. Therefore, conversion calculations are based on a standard set of typical conditions.

Worked Examples of Time Weighted Averages

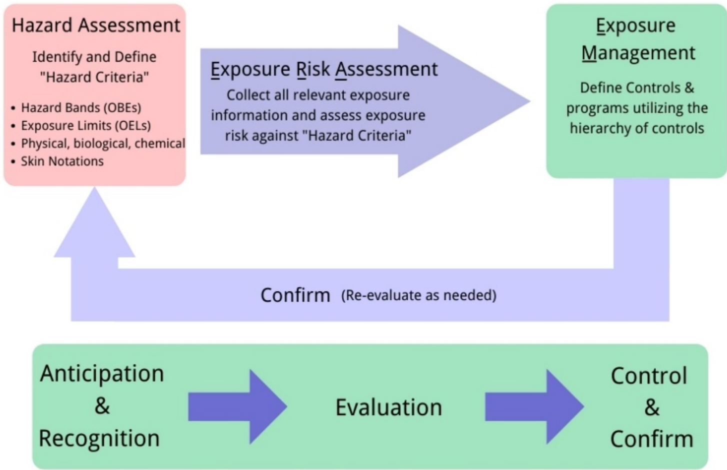
The 8-hour Reference Period

The term '8-hour reference period' relates to the procedure whereby the occupational exposures in any 24-hour period are treated as equivalent to a single uniform exposure for 8 hours (the 8-hour time-weighted average (TWA) exposure).

The 8-hour TWA may be represented mathematically by:

$$\frac{C_1 T_1 + C_2 T_2 + \ldots C_n T_n}{8}$$

Where C1 is the occupational exposure and T1 is the associated exposure time in hours in any 24-hour period.



International Examples of Exposure Limits

In contrast to the worldwide harmonised classification of chemicals by the Globally Harmonised System (GHS), Occupational Exposure Limits (OELs) at the workplace are a national affair. In different countries, OELs may either be (legally) binding or else be mere recommendations.

Determination of OELs can be health-based, technical based or risk-based.

A selection of the national approaches to setting an OEL are described in the following pages for different regions and countries.

European Union

The Chemical Agents Directive (CAD) requires that the European Commission evaluate the relationship between the health effects of hazardous chemicals and the level of occupational exposure by means of an independent scientific assessment of the latest available scientific data.

The Scientific Committee on Occupational Exposure Limits (SCOEL) gives advice to the European Commission concerning the Occupational Exposure Limit (OEL) at European level. SCOEL findings also include the results of the consultation of stakeholders for expanding the possible set of health-based data concerning hazardous substances, and for securing higher acceptance of the recommended limit values.

The CAD distinguishes two different types of limit values:

Binding OEL (BOELV):

BOELVs are binding limit values for occupational exposure to non-carcinogenic substances (health-based) as well as to carcinogenic substances (typically technical-based). BOELVs have been determined for non-carcinogenic substances, e.g. for lead and its inorganic compounds, as well as for carcinogenic substances, such as benzene, vinyl chloride monomer, and hardwood dust. For many other substances, BOELVs are under discussion.

BOELVs are published under the Carcinogen Directive 2004/37/EC, except for lead, which is mentioned in the CAD. Member States must establish a corresponding OEL that must not exceed the European BOELV. In addition to the factors that are used when determining IOELVs, certain socio-economic factors may also be considered, provided that, at all times, worker health protection is ensured.

Indicative OEL (IOELVs):

IOELVs are health-based, recommended values. They are exposure limits for any substance concentration, below which, in general, no adverse health effects are expected after short-term or daily exposure over a working lifetime.

Additional notations are allocated to some of the occupational exposure limit values in the respective lists. Those notations provide specific information on certain substance properties. Such properties can result in increased total workplace exposure in addition to inhalation exposure. Therefore, compliance with the occupational exposure limit value alone does not protect workers from the adverse health effects.

IOELVs are derived based on the latest scientific data, and of the currently available measurement techniques. If there is an IOELV established at European Community level, Member States are required to establish a national OEL, considering the Community limit.

United Kingdom

On 18 December 2011, the European Commission's third Directive on Indicative Occupational Exposure Limit Values (2009/161/EU) was implemented in Great Britain and Northern Ireland.

This Directive requires the Member States of the European Union to introduce domestic occupational exposure limits for the substances listed in the Annex to the Directive.

Additionally, the level of the domestic limit must take account of the Indicative Occupational Exposure Limit Value (IOELV).

Although the UK is no longer a member of the European Union, the UK is aligning all existing H&S legislation so that the UK Health and Safety Executive is still using workplace exposure limits (WELs)

WELs are British occupational exposure limits and are set to help protect the health of workers. WELs are concentrations of hazardous substances in the air, averaged over a specified period, referred to as a time-weighted average (TWA). Two time periods are used:

- Long-term (8 hours)
- Short-term (15 minutes)

UK HSE Document EH 40 list the WELs for hazardous substances.

Monitoring

When it is required and what should be monitored

Monitoring is appropriate (in relation to UK HSE document EH40) when:

- You need to show compliance with a Workplace Exposure Limit (WEL)
- To show that control equipment or PPE is working effectively

Monitoring can also show any spread of contamination (e.g. use of surface wipes)

The kind of monitoring that can take place could be air monitoring to show how much of a substance a worker may inhale or biological monitoring to show how much of a substance has entered the body.

Selecting the right people to take part in monitoring

Those individuals within the workplace who are exposed to hazardous substances on a regular basis or who work with substances where there may be an exposure level should be monitored on a regular basis to ensure that any exposure to substances does not have an impact on their health. A programme of monitoring should be put in place on a regular basis to ensure that individuals receive regular monitoring. It may be beneficial for the organisation to consider having a policy in place that covers workplace monitoring.

Monitoring should only be carried out by people deemed to be competent, that is familiar with monitoring techniques and the instruments required for monitoring. This is often a role associated within an Occupational Hygienist.

The health and safety professional's role in specifying the type of monitoring required

The Health and Safety professional's role in terms of specifying the type of monitoring required will look at the work that is taking place within their organisation and draw up a schedule in conjunction with workers and managers as to what workplace monitoring should take place. They work in conjunction with their Occupational Health department to see if there are any trends or whether there are legal requirements in undertaking workplace monitoring.

Over time they may develop a policy in terms of when workplace monitoring may take place based on the roles of the individuals.

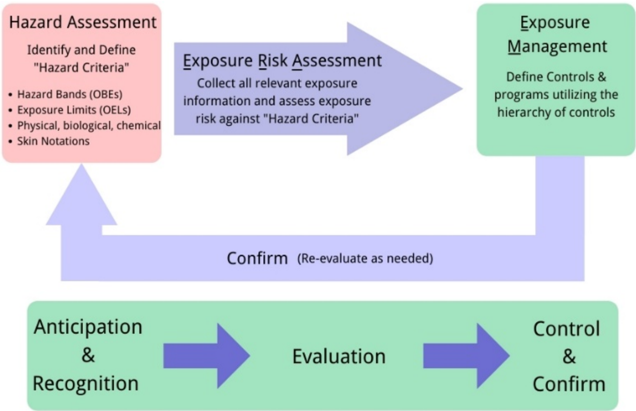
They may also bring in outside expertise to assist with the workplace monitoring – experts who specialise in workplace monitoring and have access to the necessary equipment and can spend significant time with the workers in undertaking the monitoring and analysing the results,

The outside company can then produce a report to the Health and Safety professional advising of the outcomes of any workplace monitoring and any actions that need to be taken.

The role of the occupational hygienist

Occupational hygiene (OH) - or Industrial Hygiene in the US - is the anticipation, recognition, evaluation, control, and prevention of hazards from work that may result in injury, illness, or affect the well-being of workers.

Occupational hygienists come from varied backgrounds. They can be chemists, engineers, biologists, physicists, doctors, nurses, and other professionals all of whom have chosen to apply their skills to protect the health of workers. Occupational hygiene is multidisciplinary so its practitioners must acquire a broad and solid foundation of knowledge across all these disciplines and more. Common to all practitioners is a core of knowledge that can only be described as "occupational hygiene" and a strategic approach to managing health hazards at work.



Occupational hygienists are responsible for identifying, assessing, and controlling health hazards in the workplace. They understand how chemical, physical, and biological agents may affect the health of the workforce and, in turn, the health of the business.

Occupational hygienists carry out work in a variety of settings, including factories, offices, and building sites. They are involved in hazard identification, measurement, assessment, and control of health risks in practical and cost-effective ways.

Duties vary between specialist areas and employers, but can include:

- Undertaking surveys and evaluating risks to health in the workplace.
- Accurately measuring and sampling levels of exposure, often through the precise use of specialist equipment.
- Recording facts or details of procedures in the workplace.
- Eliminating or significantly reducing risk by recommending organisational changes and selection and design relevant facilities.
- Considering all options of control, such as ventilation, containment, and personal protective equipment, and finding cost-effective solutions.
- Compiling data, writing reports, and presenting findings to the employer and clients.
- Liaising with a range of people, including employers and workers, in the process of evaluating workplaces.
- Providing clear and accurate information on complex health and safety issues.
- Training staff on health issues such as asbestos and other chemical hazard awareness.
- Persuading company management to develop effective hazard controls when required.
- Providing expert witness services.
- Liaising with regulatory bodies (such as the Health and Safety Executive HSE).

How an organisation can select a competent occupational hygienist

Occupational hygienists are generally of graduate calibre, with a strong science, mathematics or engineering educational background, and have at least three years' experience of comprehensive occupational hygiene practice.

Several organisations worldwide offer a pathway to becoming a "certified" operational hygienist. They include:

- UK: BOHS (British Occupational Hygiene Society).
- USA: ACGIH (American Conference of Governmental Industrial Hygienists).

- Australia: AIOH (Australian Institute of Occupational Hygienists).
- South Africa: SAIOH-CB (South African Institute for Occupational Hygiene).
- Malaysia: Malaysian Industrial Hygiene Association.

Type of equipment used for substance monitoring

Introduction

Air sampling involves capturing the contaminant from a known volume of air, measuring the amount of contaminant captured, and expressing it as a concentration.

The air is passed through a filter medium (normally a paper for solid contaminants and a sorbent for gases). The volume of air is measured against the amount of contaminant captured. This gives the concentration, which is expressed either as milligrams per cubic metre (mg/m3) or parts per million (ppm).

The volume of air is calculated by multiplying the flow rate through the filter medium by the time in minutes. Calibration of the flow rate is important and should be carried out before and after each sample is taken.

Sampling for particulates

There are many different methods of taking air samples, but by far the most widely used and preferred is to connect a battery-operated pump to a filter medium, via tubing. The pump should be capable of drawing air through the filter at a constant rate for a time more than 8 hours, even in adverse conditions such as extreme cold. At the end of the sampling period the filter is removed and weighed. The type of sampling head depends on the particulates being measured - such as dusts or fibres. The criteria is based around the recommendations that samples should be taken on a personal basis for an 8 hour Time Weighted Average (TWA). Other types of sampling, notably the Short-Term Exposure Limit (STEL) present no problems for the pump sampler.

The approved method for carrying out will be specified in national guidance or standards. In the UK, the HSE MDHS Guidance note 14 " General methods for sampling and gravimetric analysis of respirable and inhalable dusts" is such a method.

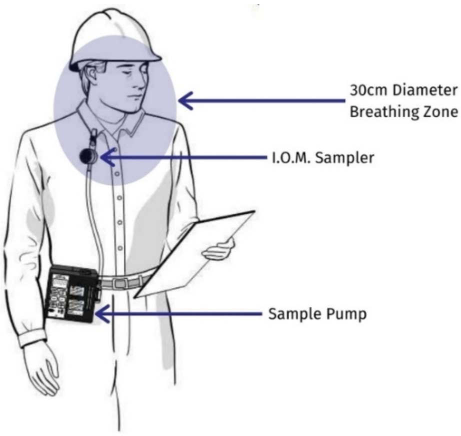


Image source - https://www.hse.gov.uk/index.htm

Sampling for total inhalable dust

For inhalable dust, the I.O.M*. Sampler is used. The filter is placed between the cassette front and the support grid, which clip together to make a one-piece unit. The whole cassette assembly is then pre-weighed before a sample is taken. After completion of the sample the whole cassette assembly is then post-weighed. The I.O.M. Sampler retains

all the particulate drawn into it using this filter/cassette combination, and eliminates problems of wall loss, whereby some of the particulate adheres to the walls of the sampler, and the resulting potential for under sampling, as experienced with other types of sampling device.

(* invented by the Institute of Occupational Medicine).

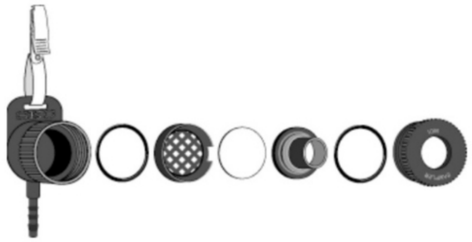


Image source - https://www.hse.gov.uk/pubns/mdhs/pdfs/mdhs14-4.pdf

Sampling for respirable dust

For respirable dust, a cyclone sampler can be used, which separates the respirable dust (approx. 12 microns and below) of the particulate from the atmosphere drawn through it. The cyclone sampler is designed so that smaller particles are carried onto the filter paper inside the cassette and larger unwanted particles drop into the grit pot.

Unlike the I.O.M sampler cassette/filter combination, the cyclone version should not be weighed as a unit. Only the filter paper is weighed pre and post sampling.

Image source - https://www.hse.gov.uk/research/rrpdf/rr825.pdf

Sampling for fibres (such as asbestos) using a cowl

A cowl is a hood that is attached to the sampling head. They come in a variety of sizes (see picture below) For the collection of fibres, cowls are used. The UK HSE guidance "Asbestos: The analysts' guide for sampling, analysis and clearance procedures" (HSG 248) specifies an open- faced filter holder and a cylindrical cowl which protects the filter head and allows a uniform deposit of fibres.

Air sampling involves drawing a known flow rate of air through a filter for a measured time, so that airborne particles are collected. The filter is then prepared for microscopical examination. A known fraction of the filtered deposit is examined using X 500 phase contrast microscopy to count all fibres seen (particles >5 µm long, <3 µm wide and a length to width (aspect ratio) of >3:1) in a known number of graticule areas. The calculated total number of fibres collected on the filter is divided by the volume of air sampled to determine the fibre concentration in terms of fibre per millilitre of air (f/ml).

Image source - https://www.hse.gov.uk/pubns/priced/hsg248.pdf

Sampling may be personal or static

Static sampling may be appropriate for:

- Background sampling to establish fibre concentrations before any activity which may lead to airborne asbestos contamination.
- Leakage testing to ensure that the steps taken to prevent the enclosure leaking are and remain effective and it is not releasing airborne respirable fibres.
- Site certification for reoccupation on completion of asbestos removal work.
- Static sampling to assess asbestos fibre concentrations inside enclosures before entry for a visual inspection.

Calibration of the sampling pump

In the case of air sampling, calibration is the setting of the air flow through the filter medium to the recommended level for the method being used. Calibration of the flow through the sampling system is important and should be checked before and after each sample is taken. There are two different levels of flow used for personal sampling:

- Dusts: Flow is usually set at 2 litres per minute
- Gases and vapours: flow is usually set at 10-200 ml per minute.

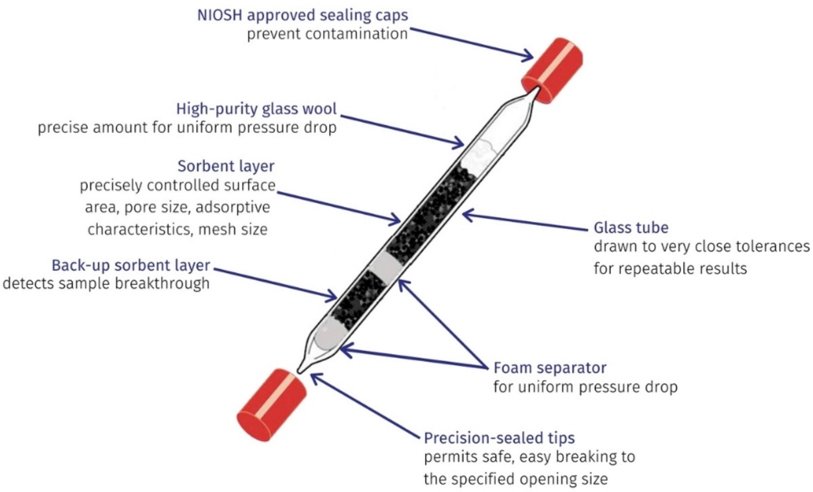
The usual method of flow measurement (calibration) for the higher levels is achieved using a rotameter (variable area flowmeter.) Both 2 litres per minute for inhalable dust using the I.O.M sampler and 2.2 litres per minute using the cyclone sampler for respirable dust can be set aside for this type of device. The flow is read from the float inside the graduated glass tube.

Image source - https://en.wikipedia.org/wiki/Rotameter

For lower flows (10-200 ml per minute) normally required for gases a bubble film calibrator is suitable. It has high accuracy and low back pressure with superior resolution compared with the rotameter. The flow is calculated by timing a bubble between two graduation marks on a glass tube with a stopwatch.

Sampling for gases and vapours

To sample for gases or vapours, especially for longer periods such as the 8-hour TWA, the use of sorbent tubes is a widely accepted method.



A Sorbent is like a sponge - soaking up the gas or vapour that is being sampled, and which can subsequently be laboratory extracted and analysed. Activated charcoal is the most used substance. Alternatives include Silica Gel and Tenax.

Once the gas or vapour has been trapped in the sorbent tube, it needs to be removed for analysis. This is achieved by using a solvent wash and heat, which drives the chemicals of the sorbent into an analytical instrument such as a gas chromatograph.

Certain gases and vapours are best suited to solid sorbents such as activated charcoal. Examples include volatile organic compounds, such as benzene, toluene, and styrene. Liquid sorbents are suitable for collecting non-reactive gases and vapours that are highly soluble in the liquid sorbent, such as the collection of methanol and butanol in water, esters in alcohol, and organic chlorides in butyl alcohol.

Gas is sampled in one of two ways:

Active sampling (using pumps and tubes)

This method uses a pump (like the pumps used for articulate sampling) to provide an airflow through sorbent solid or liquid material.

Liquid sorbents - the Midget impinger

Examples of liquid absorbent devices (known as "bubblers") include the midget impinger. The impinger is filled with 10-20 mls of liquid absorbent (such as water for collecting methanol or butanol) and is fitted to the worker's breathing zone (usually on the lapel of a coverall). As the gas/vapour is drawn through by the pump it "bubbles" and readily dissolves in the sorbent.

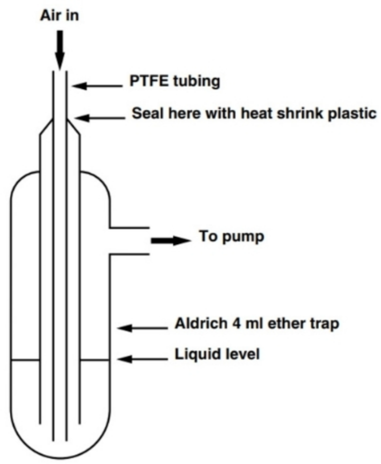


Image source - https://www.hse.gov.uk/pubns/mdhs/pdfs/mdhs86-2.pdf

Solid sorbents - activated charcoal

Activated charcoal is an excellent sorbent for most organic vapours. The relative ease with which organic vapours can be extracted from activated charcoal by carbon disulfide and be analysed subsequently by gas chromatography are reasons for its popularity.

Today, air sampling procedures using activated charcoal are widely used and form the basis of many of the official analytical methods for organic materials recommended by HSE and NIOSH.

The personal sampling process is similar to the midget impinger, as depicted in the figures below.

Passive (or diffusive) samplers

A passive (or 'diffusive') sampler is a device which is capable of taking samples of gas or vapour from the atmosphere at a rate controlled by a physical process such as diffusion through a static air layer or permeation through a membrane, onto a sorbent material, but which does not use a pump to draw air through the sampler.

There are two broad categories of passive samplers on the market today that operate on the principle of diffusion: (a) samplers requiring laboratory analysis and (b) direct-reading devices.

Direct-reading passive samplers are typically based on colourimetric techniques. The length of the colour band or the intensity of the colour change is read on a scale or compared to a chart to determine concentration levels. Passive colour tubes are a good example of a direct-reading passive sampler. These tubes simply insert into a holder and clip onto a worker's lapel. The target compound diffuses into the open-end of the tube, combines with the reagent and produces a colour change that is read from the tube scale in part-per-million-hours (ppm-hrs). The user simply divides the reading by the number of hours sampled to determine the ppm exposure.

The diffusive equivalent of an impinger is a liquid filled badge such as the Pro-Tek (TM) inorganic monitor or the SKC badge; the diffusive equivalent of the charcoal tube is the charcoal badge such as the 3M OVM.

The sampler is designed to be worn on the workers lapel. At the end of the sampling period, the holder is returned for laboratory analysis.

Active v Passive sampling

There are several advantages of each system - active and passive, such as size and weight and thus worker convenience and initial cost. However, two prime factors affecting reliability are very important.

In the main, active sampling is pretty much independent of wind speed; diffusive samplers however do not work well under minimal air movement conditions or in the other extreme, high wind conditions. Most active sampling for gases and vapours is personal on sorbent tubes that have a backup section; this enables a quality and reliability check to be performed under certain defined guidelines and leads to very reliable quantification. Most diffusive samplers do not and are not capable of this.

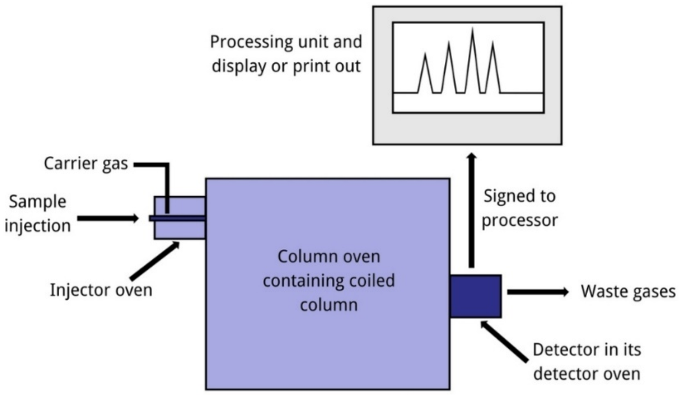
Measurement principles

Where samples of collected gas/vapours need to be analysed in a laboratory, there are two main techniques that are generally used, Gas liquid chromatography (GLC), occasionally supported by mass spectroscopy:

Gas liquid chromatography

Once the sample has been extracted from the solid or liquid collection material, very small quantities of it are injected into the GLC machine using a small syringe. The syringe needle passes through a thick rubber disc (known as a septum) which re-seals itself again when the syringe is pulled out.

The injector is contained in an oven whose temperature can be controlled. It is hot enough so that all the sample boils and is carried into the column as a gas by the helium (or other carrier gas).



The temperature of the column can be varied from about 50°C to 250°C. It is cooler than the injector oven, so that some components of the mixture may condense at the beginning of the column.

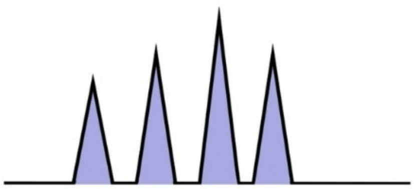
In some cases, the column starts off at a low temperature and then is made steadily hotter under computer control as the analysis proceeds.

The time taken for a particular compound to travel through the column to the detector is known as its retention time. This time is measured from the time at which the sample is injected to the point at which the display shows a maximum peak height for that compound.

Different compounds have different retention times.

At the beginning, compounds which spend most of their time in the gas phase will pass quickly through the column and be detected. Increasing the temperature a bit will encourage the slightly "stickier" compounds through. Increasing the temperature still more will force the very "sticky" molecules off the stationary phase and through the column.

The output will be recorded as a series of peaks - each one representing a compound in the mixture passing through the detector. The areas under the peaks are proportional to the amount of each compound which has passed the detector, and these areas can be calculated automatically by the computer linked to the display.



Note that it is not the peak height that matters, but the total area under the peak. In this example, the left-hand peak is both tallest and has the greatest area. That is not necessarily always so.

There might be a lot of one compound present, but it might emerge from the column in relatively small amounts over quite a long time. Measuring the area rather than the peak height allows for this.

When the detector is showing a peak, some of what is passing through the detector at that time can be diverted to a mass spectrometer. There it will give a fragmentation pattern which can be compared against a computer database of known patterns. That means that the identity of a huge range of compounds can be found without having to know their retention times.

Calculating exposure levels

To calculate exposure levels, three basic measurements are required:

- Amount collected
- Flow of air through filter
- Time of the sampling period

Example: An industrial hygienist (IH) sampled for 100 minutes at a flow rate of 0.2 litres/minute.

What is the air volume?

Flow rate × time = air volume

0.2 L/min × 100 min = **20 L**

Calculation of mg/m³:

µg analyte(mg/1000µg) = mg/m³

____

Air volume in L (m³/1000L).

Labs often report the amount of analyte found in micrograms (µg) and 1000 µg = 1 mg. 1000 L = 1 m³

Example: The chemist determined that a sample tube contained 2000 µg acetone. The IH had taken a 20 L air volume sample over a period of 8 hours.

What is the mg/m³ of acetone?

2000 µg phenol(mg/1000µg) = **100 mg/m³**

____

20 L (m³/1000L).

What is the 8hour TWA?

100 = **12.5 mg/m³** (note: the OEL for acetone is 1200 mg/m³.).

8

In the example above the exposure is well below the exposure level and no further action would be required, unless the exposure was as a result of something that is simple and cheap to rectify (such as a leaking seal on a pump).

It must be remembered, however, that when assessing the risks from exposure to hazardous substances, other routes of entry must be considered (such as skin absorption).

Monitoring strategy (with reference to HSG173)

There are many reasons for adopting a formal monitoring strategy to monitor workers' expose to airborne contaminants, including:

- Health risk assessment
- Compliance with occupational/workplace exposure levels
- To help towards the design of exposure control measures
- Checking the effectiveness of your control measures
- Informing your workers of the pattern of exposure and level of risk
- To indicate the need for health surveillance
- Establishing in-house exposure standards, where necessary
- For insurance purposes
- To contribute to epidemiological studies

Initial Appraisal

The initial appraisal is an important part of the strategy described in Figure 1. It helps you establish the need for, and the extent of, exposure monitoring. This will help you to decide on:

- The hazards.

- The potential risks.
- Whether more information is needed (e.g. do you need to carry out monitoring to obtain an estimate of the exposure of your workers to substances hazardous to health?).

The first stage of the initial appraisal requires you to find out information on a variety of factors, for example:

- The substance that your workers are exposed to.
- The hazardous and physical properties of the substance.
- The airborne forms of the substance.
- The processes or operations where exposures are likely to occur.
- The number, type, and position of the sources from which the substance may be released.
- Which groups of workers are most likely to be exposed.
- The pattern and duration of exposure.
- Work practices.
- How the release of the substance is controlled.
- Whether respiratory protective equipment and/or other personal protective equipment are worn and their effectiveness.
- What are the workplace exposure limits from other bodies or in-house standards for the substance involved?

This information can be obtained from several sources, for example:

- Labels on containers and packages.
- Manufacturers' and suppliers' safety data sheets.
- Government or HSE (enforcement agency) publications.
- Technical literature from trade associations.
- Past experience.

When you have this information, you can use simple qualitative tests to help you decide whether there may be a risk to the health of your workers, for example:

- Smoke tubes can illustrate the movement of air under the influence of draughts, general and local exhaust ventilation systems, and show what the effects are.
- A dust lamp allows you to see very fine airborne particles which are invisible under normal light. This helps you identify emission sources and watch the movement of airborne dust.
- Smell can also be used as an indicator of contamination. But remember this is an unreliable method.

Based on the information collected during the initial appraisal you may conclude that the level of exposure, by inhalation, is acceptable. If this is the case, it might not be necessary to carry out exposure monitoring.

Remember, the level of exposure of your workers to a substance hazardous to health can change. This means that your initial assessment may no longer be valid. You should always be aware of the need for exposure monitoring.

Basic survey

You will need to proceed to a basic survey when the initial appraisal suggests:

- There is an exposure risk, but the extent of the risk is uncertain
- Major changes have been made to the process, procedures, or control measures since the last assessment

- Unusual or periodic operations are planned
- A new process is being commissioned
- A new occupational/workplace exposure level or in-house standard has been set

The basic survey estimates your employees' personal exposure and provides an indication of the efficiency of process and engineering controls.

In the case of a basic survey it is best to look at worst-case situations, such as the 'dirtiest', or situations your employees make the most complaints about.

Before monitoring you need to identify those employees likely to be at significant risk of exposure along with the conditions giving rise to them.

You can use semi-quantitative methods to estimate personal exposure. These give you a rough numerical estimate of exposure. Some semi-quantitative methods are comparatively inexpensive and easy to use.

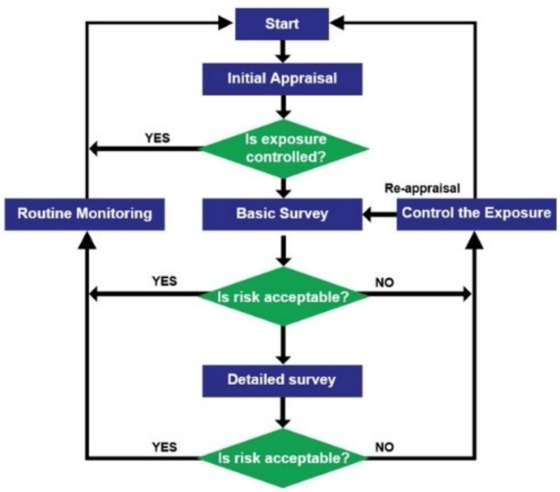
Semi-quantitative methods range from simple techniques, such as chemical indicator tubes (where the absorbent granules in the tube change colour when a known amount of air, containing a chemical, is drawn through) to more complex methods which require specialist knowledge, including:

- Computer exposure modelling
- Organic vapour analysers such as photo-ionisation detectors, portable gas chromatographs and infra-red analysers

Alternatively, validated laboratory-based sampling and analytical techniques can be used.

The basic survey may highlight defects and deficiencies in control strategies. Based on this and information gathered during the initial appraisal you may conclude that the control of inhalation exposure is acceptable. If the conclusion is not certain, you have two choices:

- Carry out a detailed survey and take remedial action as necessary
- Take direct action to control exposure



Detailed survey

You can use this approach when:

- The extent and pattern of exposure cannot be confidently assessed by a basic survey
- Exposure is highly variable between employees doing similar tasks
- Carcinogenic substances, respiratory sensitizers or mutagens are involved
- The initial appraisal and basic survey suggest that:
- The time-weighted personal exposure may be very close to any national exposure limits or in-house standard
- The cost of additional control measures cannot be justified without evidence of the extent of exposure variability
- Undertaking major maintenance and one-off jobs such as plant decommissioning

A detailed survey is likely to involve techniques already mentioned for the initial appraisal and basic survey. This will be in conjunction with more detailed monitoring of your employees' potential exposure to substances hazardous to health.

A detailed survey is most suited to complex processes and will require an in-depth investigation of the process and its environment.

For example:

- Procedures involved in the process
- Work practices
- Maintenance procedures including the type and frequency
- Control measures in use and their suitability
- Protective equipment provided to your employees and its suitability
- Previous monitoring results
- Results of health surveillance programmes
- Information and instruction provided to your employees for carrying out the tasks involved
- The extent of the training provided to your employees

A detailed survey usually requires more specialist knowledge than an initial appraisal or basic survey.

Routine monitoring

When you decide that the risk to your employees has been adequately controlled, you may decide that you need to set up a routine monitoring programme to ensure that the control measures stay effective.

Routine monitoring can be time-consuming and expensive over the long term. Consequently, if you think that you may not be complying with an occupational exposure limit it can be more cost- effective for you to invest in better control measures. This reduces the:

- Need for expensive routine monitoring
- Health risks for your workforce

Remember, there are some simple and inexpensive instruments available which can provide information on the continued performance of control methods, for example:

- Pressure sensing devices fitted to ventilation systems
- Smoke tubes
- Dust lamps

For the results of a routine monitoring programme to be effective in protecting the health of your employees you need to be able to compare them with those obtained from previous monitoring exercises. This requires that the programme is well planned.

You need to consider:

- The similarity of the processes and tasks monitored
- Where and at what stage of the process the monitoring was carried out
- The method of collecting and analysing the samples

If a programme is not well planned it can produce a large volume of results and paperwork without being of any actual use in making sure that your employees' health is being protected.

The frequency of routine surveys will vary. The nearer the measured exposure is to the occupational exposure limit the more frequently you will need to monitor.

With regards to COSHH regulation 10(1), exposure monitoring means using suitable techniques to assess the extent of employees' exposure to substances hazardous to health via all routes (inhalation, ingestion and/or skin). The information gathered during exposure monitoring can help an employer assess whether the control of employees' exposure is adequate.

Exposure monitoring will generally be required if:

- The risk assessment shows that an initial exploratory monitoring exercise is necessary to reach an informed and valid judgement about the risks.
- Failure or deterioration of the control measures (e.g. a lack of containment, or LEV not performing as intended) could result in a serious health effect, either because of the toxicity of the substance or because of the extent of potential exposure, or both.
- Measurement is required to be sure that an exposure limit or any self-imposed (in-house) exposure standard is not exceeded.
- Any change in the conditions affecting employees' exposure means that adequate control of exposure is no longer being maintained, e.g. an increase in the quantity of a substance used or from changing systems of work or introducing new plant.
- It is needed as an additional check on the effectiveness of any control measure provided.
- The risk assessment shows it is needed to monitor for the presence of any biological agents outside the primary physical containment.

Exposure monitoring will not be appropriate:

- If suitable techniques for sampling, analysis and quantification do not exist, or cannot be devised.
- If the employer can demonstrate that an alternative method of evaluation has been used to ensure that exposure is adequately controlled. (for example, light-scattering techniques, smoke tubes, air velocity measurements; where any breach of containment is monitored with fixed site monitors and warning alarms - for example, as in laboratory fume cupboards).

The difference between personal and static sampling

Personal monitoring

Measuring your employees' personal exposure, by inhalation, to substances hazardous to health is not the same as measuring the amount at a particular fixed site in the workplace. Fixed sites can be either:

- At the source of emission of a substance hazardous to health
- At another area in the workplace, away from the source

Personal monitoring is used to establish the concentration of an airborne substance within the employee's breathing zone. You will need to consider whether personal exposure monitoring will be useful when assessing the risks to your employees from working with substances hazardous to health.

Remember, exposure monitoring is not an alternative to the adequate control of exposure and programmes can be time-consuming, labour-intensive, and expensive. Therefore, it is important that you establish:

- A clear need for monitoring
- An understanding of the factors likely to influence the exposure; and a strategy which is fit for the purpose

Fixed place (or static) monitoring

Most exposures refer to personal exposures. You can also use fixed place or static monitoring to obtain information on the likely sources contributing to the exposure. However, fixed place monitoring does not usually reflect the amount that one of your employees could breathe in, which determines the risk to health.

You may take fixed place samples:

- To check the effectiveness of your control measures
- To identify emission sources
- To determine background workplace contaminant concentrations
- If there are no suitable personal monitoring methods available
- When wearing personal monitoring equipment may introduce additional hazards
- When continuous monitoring alarm systems are installed

Interpreting a Hygienist's Report

The ability to write effective reports helps occupational hygienists achieve their goals of preventing and controlling workplace hazards. Effective occupational hygiene reports provide employers with clear and critical information to support their Risk Assessment and manage health risks.

The reports can vary depending on the purpose of the monitoring and the needs of the client. However, the basic contents remain the same. Regardless of the type of report, all reports should include the following common elements:

- Title
- Executive summary
- Introduction
- Process description
- Methods and measurements
- Results and discussion
- Conclusions and recommendations

A Health and Safety Practitioner must read and interpret a hygienist's report and decide whether the strategy and methods used are suitable and that the results are valid, reliable, representative, and correctly evaluated.

Whilst the H&S Practitioner is not an expert in Occupational Hygiene, they should be able to scrutinise the methodology used and compare this against recognised standards.

Various sources of standards exist, such as the HSE document HSG173 "Monitoring Strategies for Toxic Substances" or the HSE's "Methods for the Determination of Hazardous Substances" series of guidance and, for comparing sampling results against a standard, HSE document EH40 "Workplace Exposure Limits".

9.10: Biological Agents

The main types of biological agent

Fungi

Fungi include mushrooms, moulds, and yeasts. They obtain nutrients by absorbing organic material from their environment (decomposers), through symbiotic relationships with plants (symbionts), or harmful relationships with a host (parasites). Fungi reproduce by releasing spores.

Fungi have a worldwide distribution and grow in a wide range of habitats, including extreme environments such as deserts or areas with high salt concentrations, as well as in deep sea sediments.

The human use of fungi for food preparation or preservation and other purposes is extensive and has a long history. Mushroom farming and mushroom gathering are large industries in many countries.

Many species of fungi produce metabolites that are major sources of pharmacologically active drugs. Widespread use of antibiotics for the treatment of bacterial diseases, such as tuberculosis, syphilis, leprosy, and others began in the early 20th century and continues to date.

Athlete's foot is a common skin infection of the feet caused by fungus. The condition is typically acquired by coming into contact with infected skin, or fungus in the environment. Common places where fungi can survive are around swimming pools and in locker rooms. Fungi may also be spread from animals. For example, pets, such as dogs and cats, can have ringworm, and you can catch it by stroking them.

Fungi may also be inhaled. Mould and fungus often grow on the walls of damp buildings. Their spores are carried through the air. When a wall is impregnated with moisture, mould and fungus are likely to grow. They are commonly found in basements, kitchens, and bathrooms. Many of the moulds produce mycotoxins, which are toxic to humans.

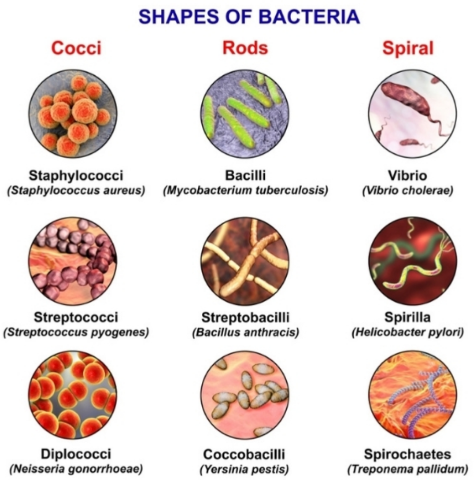
They are emitted by the moulds, and are inhaled. They can slowly wear down the immune system, and cause allergic or respiratory problems, including:

- Eye, nose, and throat irritation
- Coughing or congestion
- Aggravation of existing asthma
- Fatigue

Bacteria

Bacteria are single celled microbes.

Bacteria are classified into 5 groups according to their basic shapes: spherical (cocci), rod (bacilli), spiral (spirilla), comma (vibrios) or corkscrew (spirochaetes). They can exist as single cells, in pairs, chains, or clusters.



Bacteria are found in every habitat on Earth: soil, rock, oceans, and even arctic snow. Some live in or on other organisms including plants and animals including humans. There are approximately 10 times as many bacterial cells as human cells in the human body. A lot of these bacterial cells are found lining the digestive system. Some bacteria live in the soil or on dead plant matter where they play an important role in the cycling of nutrients. Some types, cause food spoilage and crop damage but others are incredibly useful in the production of fermented foods such as yoghurt and soy sauce. Relatively few bacteria are parasites or pathogens that cause disease in animals and plants.

Salmonella food poisoning is the most common reported cause of food borne illness or food poisoning. Medically known as salmonellosis, it is a type of bacterial infection caused by a variety of types of Salmonella bacteria.

Legionellosis is a collective term for diseases caused by legionella bacteria including the most serious Legionnaires' disease, as well as the similar but less serious conditions of Pontiac fever and Lochgoilhead fever. Legionnaires' disease is a potentially fatal form of pneumonia and everyone is susceptible to infection. Potential sources of legionella in the workplace include cooling towers, hot and cold-water systems, and spa pools.

Viruses

Viruses are the smallest of all the microbes. They are said to be so small that 500 million rhinoviruses (which cause the common cold) could fit on to the head of a pin.

Almost every ecosystem on Earth contains viruses. They are considered the most abundant biological entity on the planet.

Viruses are unique microorganisms because they cannot reproduce without a host cell. After contacting a host cell, a virus will insert genetic material into the host and take over that host's functions. The cell, now infected, continues to reproduce, but it reproduces more viral protein and genetic material instead of the usual cellular products. It is this process that earns viruses the classification of "parasite."

Viruses only exist to make more viruses. The virus particle attaches to the host cell before penetrating it. The virus then uses the host cell's machinery to replicate its own genetic material.

Blood-borne viruses (such as HIV and Hepatitis) are transmitted by blood, or other body fluids containing the virus. This happens when the blood or fluids enter the body of a susceptible person.

The rate of viral transmission varies depending on how the person has been exposed to the virus (the route of transmission), the type of virus, how much of the virus the carrier has in their body, and the immune status of the exposed person. This can be caused in the health care profession by skin puncture by blood-contaminated sharp objects (e.g. needles, instruments, or glass).

The Covid19 pandemic is perhaps a stark reminder of the deadly effects of a virus. COVID-19 is more likely to go deeper than viruses like the common cold. The lungs might become inflamed, making breathing difficult. This can lead to pneumonia, an infection of the tiny air sacs inside the lungs where the blood exchanges oxygen and carbon dioxide.

Protozoa

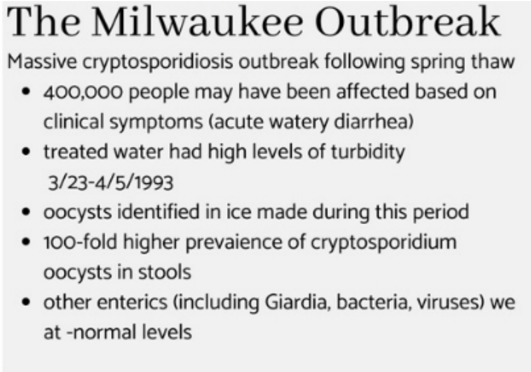
Protozoa are single celled organisms. They come in many different shapes and sizes ranging from an Amoeba which can change its shape to Paramecium with its fixed shape and complex structure. They live in a wide variety of moist habitats including fresh water, marine environments, and the soil.

Some are parasitic, which means they live in other plants and animals including humans, where they cause disease. Plasmodium, for example, causes malaria. Malaria is a disease caused by protozoa that live in the blood. It is passed to a person by an insect vector, the mosquito.

Protozoa love moisture and often spread diseases through contaminated water. Cryptosporidium is another example of a protozoa.

In 1993, Milwaukee experienced the largest documented drinking water outbreak in US history. Caused by the chlorine-resistant parasite Cryptosporidium, the outbreak affected over 400,000 people—25 percent of Milwaukee's population in 1993—and resulted in over $96 million in combined healthcare costs and productivity losses.


Sentinel
Packer Plus
Boil water, mayor says
Safety of drinking supply probed in wake of mystery epidemic



Sources of Biological Agents

Biological agents come from three main sources: humans, animals, and the environment.

Humans

Fungal, bacterial, and viral infections can be passed from person to person. For example, this can be because of a transfer of body fluids (such as with viral HIV or hepatitis), fungal transfer from infected skin (such as "Athlete's foot"), or the transfer of "flu" (influenza virus) from droplets formed when coughing or sneezing, or shaking hands with someone who has the flu.

Animals

Animals can transfer many serious diseases. For example, Rabies is a disease that affects the nervous system of mammals. It is caused by a virus and is typically spread by an infected animal biting another animal or person. Rabies is a fatal disease. It cannot be treated once symptoms appear. Luckily, vaccination can effectively prevent rabies. Another example is fungal ringworm, which can be transferred to humans by stroking infected cats or dogs. The anthrax bacteria can be found on farm animals, and in some rare cases can infect workers who work with wool or animal hides.

The Environment

Perhaps the most well know work related example of an environmental source is Legionellosis (Legionnaires disease), caused by Legionella bacteria and which is commonly found in water courses, such as rivers, lakes, and reservoirs. However, the main occupational exposure to legionella bacteria is through water sprays (showers, fire hose reels), air conditioning systems, and cooling towers, which create a fine mist which can be inhaled.

Another example is the protozoa Cryptosporidium, which may be found in water sources (such as sewers or water treatment plants) that have been contaminated with faeces from infected humans or animals.

Animals infect the environment by urinating or defecating. Rat urine contains a bacterium called Leptospira. Since rats commonly live near water, these water sources can be contaminated. Workers who work in direct contact with water sources such as rivers, lakes, or sewers, can get infected through water entering cuts in their skin.

The Special Properties of Biological Agents

Many biological agents have special properties that complicate the risk that they present. Before we go any further, here are three important definitions:

Infectious - when a biological agent is transferred via the environment e.g. airborne, from water droplets.

Contagious - when a biological agent is spread from organism to organism via bodily fluids e.g. malaria (mosquito to humans) or the HIV virus.

Infected - when a person or organism shows signs that the biological agent is in the system e.g. a raised white blood cell count in humans indicates that the immune system is fighting a bacterial or viral infection. Other signs could be visual physical symptoms such as sickness, flu symptoms, etc.

Zoonotic diseases - diseases of animals that can cause infection when transmitted to humans.

Rapid Mutation Period

It is the aim of any biological organism to survive. Biological agents are tackled by the host immune system via the white blood cells. The white blood cells will recognise if there is an existing immunity (i.e. if the body has dealt with the agent previously). If the biological agent can mutate, any immunity previously built up by the host will be ineffective and the host body will need to fight the agent from scratch.

To mutate, the biological agent changes its DNA structure in order to survive. Bacteria can mutate and become resistant to antibiotics which is a big concern for medical professionals at the moment. It is thought that this has been caused by over-prescribing of antibiotics instead of allowing a body to develop its own resistance to an agent. Due to the over exposure to the antibiotics, bacteria have altered their genetic make-up to develop this resistance. It is also possible that Legionella is a pathogen that had mutated and was not actually a new bacteria when Legionnaire's Disease was discovered in 1976.

Other common mutations occur within viruses which can change the way in which they are transferred from host to host or to act in a different way thus presenting a change in symptoms in the host. A good example of this is the flu virus. There are so many different strains of flu virus because the virus regularly mutates. Therefore a different flu vaccination is developed every year and why it is not effective against all strains of flu. The HIV virus also mutates and as such is regularly demonstrating that it can bypass the body's immune system in the host and therefore it is proving challenging for researchers looking to find a cure.

An Incubation Period

There is usually a time delay between when a person is infected and when they show signs of the disease. For example, with Anthrax the incubation period is 1 to 6 days. The flu is 1 to 3 days. HIV is 2 to 3 weeks or more. During the incubation period, although no physical symptoms may be present yet, a person's white blood cell count will show as being raised as this is the part of the blood that the immune system uses to travel through the body to fight off any infections. A raised white blood count indicates that the immune system is active.

Infectiousness

As mentioned above, infections can spread in different ways and it depends on the biological agent.

Biological agents can spread through:

- The air as small droplets (droplet spread) or tiny aerosol particles (airborne spread)
- Contact with faeces and then with the mouth (faecal-oral spread)
- Contact with the skin or mucus membranes (the thin moist lining of many parts of the body such as the nose, mouth, throat, and genitals)
- The environment such as surfaces, food, or water

- Blood or other body fluids (for example, urine, saliva, breast milk, semen, and vaginal secretions)

Biological agents can spread:

- Directly from person to person
- Indirectly from an infected person to the environment (for example, door handles, bench tops, and toilets) and then to another person who comes in contact with the contaminated environmental source

Biological agents can enter the body through the:

- Mouth
- Respiratory tract
- Eyes or other mucus membranes
- Genitals
- Broken skin

Some infections are spread when an infected person talks, coughs or sneezes small droplets containing infectious agents into the air. Due to their size, these droplets in the air travel only a short distance (around a metre) from the infected person before falling. The droplets in the air may be breathed in by those nearby. Spread can also occur by touching the nose or mouth with droplet contaminated hands.

Sometimes a biological agent can enter the body on the food we consume.

Some biological agents can stay active outside the body for over long periods of time in the right conditions e.g. legionella. Other agents tend to die almost immediately.

Infection of a person depends on a combination of events that include the host transferring the agent to another host effectively. If the new host has no immunity or the agent mutates, infection can occur.

The Ability to Multiply Rapidly

Once inside the body, the agents can multiply quickly. The rate of change makes it very difficult for the body to detect and fight the biological agent.

Some conditions support the rapid multiplication of biological agents. In particular, pH., temperature, food and moisture. Salmonella is a condition that affects the gut and is transferred via food that is consumed or by touching infected surfaces. Most Salmonella serotypes can grow over the temperature range 7 to 48°C. Legionella bacteria multiply between 20 to 50°C especially as stagnant water tends to carry the nutrients required for the bacteria. E.Coli multiply extremely quickly and thrive at temperatures of 10 to 45°C. Under ideal conditions, individual E.Coli cells can double every 20 minutes. This can lead to over 2 billion bacteria within 24 hours.

The special properties of Zoonoses/vector-borne diseases

Zoonose diseases are diseases that can be transmitted from animals to people or, more specifically, a disease that normally exists in animals but that can infect humans. For example, Salmonella, Anthrax and Psittacosis. Groups at risk include farmers, zookeepers, and pet shop workers.

Vector-borne diseases are diseases that results from an infection transmitted to humans (from bites) and other animals by blood-feeding vermin, such as mosquitoes, ticks, and fleas. For example, Malaria, Lyme disease and Dengue fever.

Common ways of infection from these diseases includes:

- Direct contact with saliva, blood, urine, mucous, faeces of an infected animal. Examples include touching animals, bites, or scratches.
- Indirect contact by coming into contact where animals live or roam or surfaces that have been contaminated with germs. Examples include pet habitats, chicken coops, plants, and soil.

Animal Influenza

Influenza is a disease common to man and a limited number of lower animal species mainly horses, pigs, domestic and wild birds, wild aquatic mammals such as seals and whales, minks, and farmed carnivores.

There are 3 types of influenza viruses A, B and C. Types B and C are human viruses mainly affecting young children and causing a mild disease. Type A virus is an important type as far as cross-species infections are concerned.

Influenza type A is distributed worldwide and usually, causes a mild respiratory disease in humans and animals. Human influenza epidemics due to new epidemic strains occur at regular intervals of 2 to 3 years and affect mainly elderly people. However, influenza is a potentially devastating disease in both humans and animals thereby very important for both human and veterinary medicine.

Birds, especially aquatic birds, represent a vast reservoir of type A influenza viruses. These viruses have the capacity to spread to many lower mammalian species and sometimes cause high morbidity and mortality. A small number of cases of animal influenza in humans has been described in the past. In these cases, the virus originated from pigs, seals, ducks, and chicken.

In birds, highly pathogenic avian influenza is an extremely contagious and aggressive disease that causes rapid systemic illness and death in susceptible birds. Domestic chickens and turkeys are most severely affected. Mortality in these birds often exceeds 50%. From 1959 to 2003 only 21 outbreaks occurred worldwide, mainly in the Americas and Europe. Although all had serious consequences for the poultry industry, most remained geographically contained.

Avian influenza A viruses may be transmitted from animals to humans in two main ways:

- Directly from birds or from avian influenza A virus-contaminated environments to people.
- Through an intermediate host, such as a pig.

The reported signs and symptoms of low pathogenic avian influenza (LPAI) A virus infections in humans have ranged from conjunctivitis to influenza-like illness (e.g., fever, cough, sore throat, muscle aches) to lower respiratory disease (pneumonia) requiring hospitalisation. Highly pathogenic avian influenza (HPAI) A virus infections in people have been associated with a wide range of illness from conjunctivitis only, to influenza-like illness, to severe respiratory illness (e.g. shortness of breath, difficulty breathing, pneumonia, acute respiratory distress, viral pneumonia, respiratory failure) with multi-organ disease, sometimes accompanied by nausea, abdominal pain, diarrhoea, vomiting, and sometimes neurologic changes.

The best way to prevent infection with avian influenza A viruses is to avoid sources of exposure. Most human infections with avian influenza A viruses have occurred following direct or close contact with infected poultry.

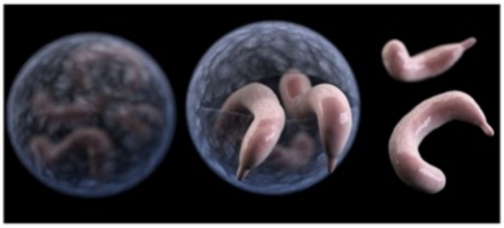
People who have had contact with infected birds may be given influenza antiviral drugs preventatively. While antiviral drugs are most often used to treat flu, they also can be used to prevent infection in someone who has been exposed to influenza viruses. When used to prevent seasonal influenza, antiviral drugs are 70% to 90% effective.

Cryptosporidiosis

Cryptosporidium Parvum is a microscopic parasite that causes the diarrheal disease cryptosporidiosis. Both the parasite and the disease are commonly known as "Crypto."

There are many species of Cryptosporidium that infect animals, some of which also infect humans. The parasite is protected by an outer shell that allows it to survive outside the body for long periods of time and makes it very tolerant to chlorine disinfection.

While this parasite can be spread in several different ways, water (drinking water and recreational water) is the most common way to spread the parasite. Cryptosporidium is a leading cause of waterborne disease among humans in the United States.



Symptoms of cryptosporidiosis generally begin 2 to 10 days (average 7 days) after becoming infected with the parasite. The most common symptom of cryptosporidiosis is watery diarrhoea. Symptoms include:

- Watery diarrhoea
- Stomach cramps or pain
- Dehydration
- Nausea
- Vomiting
- Fever
- Weight loss

Some people with Crypto will have no symptoms at all.

Symptoms usually last about 1 to 2 weeks (with a range of a few days to 4 or more weeks) in persons with healthy immune systems. Occasionally, people may experience a recurrence of symptoms after a brief period of recovery before the illness ends. Symptoms can come and go for up to 30 days.

While the small intestine is the site most commonly affected, in immune compromised persons Cryptosporidium infections could possibly affect other areas of the digestive tract or the respiratory tract. People with weakened immune systems may develop a serious, chronic, and sometimes fatal illness.

Occupational exposure to Cryptosporidium may occur in those who:

- Are in contact with infected animals, particularly calves and lambs, or humans.
- Are in contact with materials from infected animals, particularly faeces.
- Are in contact with water contaminated with animal faeces.

Occupations, where there may be a risk of occupationally acquired cryptosporidiosis, include:

- Farm workers.
- Abattoir workers, meat processing plant workers and butchers.

- Veterinary surgeons.
- Workers in outdoor leisure industries in contact with water, e.g. water sports instructors.
- Sewage and wastewater workers.
- Construction, demolition, building renovation workers, where there is stagnant water.
- Healthcare and care workers.

The following control measures reduce the risk of infection:

- Good occupational hygiene practices should be followed, especially washing with warm water and soap.
- Cuts and abrasions should be covered with waterproof plasters.
- Suitable protective clothing should be worn. For example, gloves, clean coveralls, and waterproof boots.
- A suitable disinfectant should be used. The parasite is resistant to most common disinfectants. Hydrogen peroxide is commonly used. Chlorine is NOT effective.
- No eating or drinking in work areas, to avoid the faecal-oral transmission route. Separate eating facility should be provided.
- The overalls should be regularly changed, and arrangements made for laundering.
- Equipment and surfaces should be disinfected after water contact.

Malaria

Malaria is a mosquito-borne disease caused by a parasite.

People with malaria often experience fever, chills, and flu-like illness. Left untreated, they may develop severe complications and die. In 2015, an estimated 214 million cases of malaria occurred worldwide, and 438,000 people died, mostly children in the African Region.

Infection with malaria parasites may result in a wide variety of symptoms, ranging from absent or very mild symptoms to severe disease and even death. Malaria disease can be categorised as uncomplicated or severe. In general, malaria is a curable disease if diagnosed and treated promptly and correctly.

Uncomplicated Malaria: the classical (but rarely observed) malaria attack lasts 6 to 10 hours. It consists of:

- A cold stage (sensation of cold, shivering).
- A hot stage (fever, headaches, vomiting, seizures in young children.
- And finally, a sweating stage (sweats, return to normal temperature, tiredness).

Severe Malaria: Severe malaria occurs when infections are complicated by serious organ failures or abnormalities in the patient's blood or metabolism. The manifestations of severe malaria include:

- Cerebral malaria, with abnormal behaviour, impairment of consciousness, seizures, coma, or other neurologic abnormalities.
- Severe anaemia due to the destruction of the red blood cells.
- Acute respiratory distress syndrome (ARDS), an inflammatory reaction in the lungs that inhibits oxygen exchange, which may occur even after the parasite counts have decreased in response to treatment.
- Abnormalities in blood coagulation.
- Low blood pressure caused by cardiovascular collapse.
- Acute kidney failure.
- Hypoglycaemia (low blood glucose). Hypoglycaemia may also occur in pregnant women with uncomplicated malaria, or after treatment with quinine.

Severe malaria is a medical emergency and should be treated urgently and aggressively.

Control measures to minimise the risk when visiting, or working in high-risk malaria areas include:

- Provide screening to all rest, accommodation, and recreational areas to prevent mosquitoes from entering.
- Provide beds impregnated with insecticides and provide bed nets around the beds.
- Provide mosquito repellents to workers.
- Ensure workers wear long sleeved shirts and trousers.
- Spray the surrounding areas with pesticides.
- Carry out malaria awareness campaigns on precautions to take, and early signs of malaria.
- Provide anti-malarial tablets if necessary.

Psittacosis

Psittacosis is a zoonotic infectious disease caused by a bacterium called Chlamydophila psittaci. It is contracted from infected parrots, such as macaws, cockatiels and budgerigars, and pigeons, sparrows, ducks, hens, gulls, and many other species of bird.

Humans can catch psittacosis from an infected bird in several ways. Simply handling the bird or breathing in fine particles of its urine, faeces, or other bodily excretions may lead to an infection. You may also become infected if the bird bites you or if you kiss the bird (touch your mouth to its beak).

The main groups at risk include bird owners, aviary, and pet shop workers, poultry workers, and veterinarians. Outbreaks of psittacosis in poultry processing plants have been reported. However, it can also affect workers who work in buildings that are infested with birds such as pigeons, especially if large amounts of bird droppings can accumulate.

The disease typically resembles the flu or pneumonia. Symptoms typically begin approximately 10 days after exposure but may take as few as four or as many as 19 days to show up.

It has many of the symptoms that you might associate with the flu, including:

- Fever and chills
- Nausea and vomiting
- Muscle and joint pain
- Diarrhoea
- Weakness
- Fatigue
- A cough, typically dry

Control measures include:

- Wearing protective clothing when handling potentially infected birds or cleaning their droppings. E.g. wear gloves, coveralls or disposable gowns, disposable caps, protective eyewear, and a filter mask.
- Frequent removal of droppings.
- Prevent aerosols by damping down dropping with a liquid disinfectant prior to removal and double bag all waste.
- Practising good hygiene by washing hands thoroughly after work activities described above.

Other Biological Diseases - Blood-Borne Viruses

Blood-borne viruses (BBVs) are viruses that some people carry in their blood and can be spread from one person to another. Those infected with a BBV may show little or no symptoms of serious disease, but other infected people may be severely ill. You can become infected with a virus whether the person who infects you appears to be ill or not. They may be unaware they are ill as some persistent viral infections do not cause symptoms. An infected person can transmit (spread) blood-borne viruses from one person to another by various routes and over a prolonged time.

The most prevalent BBVs are:

- Hepatitis B (HBV) and hepatitis C.
- Human immunodeficiency virus (HIV), a virus which causes acquired immunodeficiency syndrome (AIDS), a disease affecting the body's immune system.

Health care workers are the biggest occupational risk from blood borne viruses. In the UK, contaminated sharps exposure in healthcare workers is confirmed by Public Health England as the most common mode of occupational exposure to blood-borne viruses, though transmission rates remain low, as a proportion of reported incidents.

Additional risk occupations include:

- Embalming and crematorium work
- Emergency services (ambulance, fire, police, rescue)
- Hairdressing and beauticians' work
- Laboratory work (forensics, research, etc.)
- Local authority services (street cleaning, park maintenance, refuse disposal, public toilet maintenance)
- Medical or dental equipment repair
- Needle exchange services
- Sewage processing
- Tattooing, ear, and body piercing

Hepatitis B (HBV) is a liver infection caused by the Hepatitis B virus (HBV). Hepatitis B is transmitted when blood, semen, or another body fluid from a person infected with the Hepatitis B virus enters the body of someone who is not infected. For some people, hepatitis B is an acute, or short-term, illness but for others, it can become a long-term, chronic infection. Chronic Hepatitis B can lead to serious health issues, like cirrhosis or liver cancer. The best way to prevent Hepatitis B is by getting vaccinated.

Once inside the host, HBV is transported in the blood to the liver, where it infects liver cells. The incubation period of acute HBV infection is usually about 75 days but can range from 45 to 200 days. The virus spreads in the liver and causes a spectrum of disease, ranging from acute hepatitis to chronic liver disease and liver tumours.

A small proportion of patients with acute infection suffer liver failure, although most recover from the infection. Asymptomatic infection (infection without symptoms) and illness without jaundice do occur, particularly in children and the immunocompromised (those with an impaired immune system).

Chronically infected individuals are often referred to as HBV carriers.

Hepatitis C(HBC): Post-transfusion infectious hepatitis caused by agents other than hepatitis B has long been recognised. These cases, at one time, were collectively termed 'non-A non-B hepatitis', and the main cause is now known to be the hepatitis C virus (HCV). HCV has a worldwide prevalence, although rates of infection vary,

depending on socio-economic factors, such as intravenous drug use and medical practices because it is primarily transmitted via the direct introduction of the virus into the blood.

Once inside the host, the HCV is transported in the blood to the liver, where it infects liver cells, although other types of cell, including blood cells, may also be infected. The incubation period for acute HCV infection is usually around 70 days but can range from 2 to 26 weeks. The acute phase of HCV infection is often without symptoms, or mild.

Patients with acute HCV infection go on to develop chronic infection with a variable degree of hepatitis, with the risk of cirrhosis and, in a smaller number, primary liver cancer several decades later.

Human immunodeficiency viruses: HIV infects certain types of white blood cell. This usually results in the death of these cells. The hallmark of HIV infection is the gradual loss of helper T-lymphocytes from an infected person. This ultimately leads to a state of generalised immunodeficiency and AIDS. In some cases, infection of the central nervous system occurs, often leading to progressive brain damage.

Worldwide, most infections have been transmitted sexually or by blood - the latter being principally via blood transfusion or from contaminated injecting equipment.

In occupations where there is a risk of exposure to BBVs, the following measures to prevent or control risks apply. You may need to adapt them to your local circumstances in ensuring a safe system of work:

- Prohibit eating, drinking, smoking and the application of cosmetics in working areas where there is a risk of contamination.
- Prevent puncture wounds, cuts, and abrasions, especially in the presence of blood and body fluids.
- When possible, avoid the use of, or exposure to, sharps such as needles, glass, metal, etc. If unavoidable, take care when handling and disposal.
- Consider the use of devices incorporating safety features, such as safer needle devices and blunt-ended scissors. Within UK legislation there is now a legal requirement for organisations to implement safer sharp products.
- Cover all breaks in exposed skin by using waterproof dressings and suitable gloves.
- Protect the eyes and mouth by using a visor, goggles, or safety spectacles and a mask, where splashing is possible.
- Avoid contamination by using water-resistant protective clothing. Wear rubber boots or plastic disposable overshoes when the floor or ground is likely to be contaminated.
- Use good basic hygiene practices, such as hand washing with soap and warm water.
- Control contamination of surfaces by containment and using appropriate decontamination procedures.
- Dispose of contaminated waste safely.

Legionellosis

Legionellosis is a collective term for diseases caused by legionella bacteria including the most serious Legionnaires' disease, as well as the similar but less serious conditions of Pontiac fever and Lochgoilhead fever. Legionnaires' disease is a potentially fatal form of pneumonia and everyone is susceptible to infection. The risk increases with age, but some people are at higher risk including:

- People over 45 years of age
- Smokers and heavy drinkers
- People suffering from chronic respiratory or kidney disease
- Diabetes, lung, and heart disease

- Anyone with an impaired immune system

Symptoms and Effects

Initial symptoms usually include flu-like symptoms, such as:

- Mild headaches
- Muscle pain
- High temperature (fever)
- Chills
- Tiredness
- Changes to your mental state, such as confusion

Once bacteria begin to infect your lungs, you may also experience symptoms of pneumonia, such as:

- A persistent cough, which is usually dry at first, but as the infection develops you may start coughing up phlegm or, rarely, blood
- Shortness of breath
- Chest pains

Severe infection can cause some organs, such as your lungs or kidneys, to stop working properly. Another complication is septic shock. An estimated 10% of otherwise healthy people who develop Legionnaires' disease die due to problems like these.

Where it occurs

The bacterium Legionella pneumophila and related bacteria are common in natural water sources such as rivers, lakes, and reservoirs, but usually in low numbers.

People contract Legionnaires' disease by inhaling small droplets of water (aerosols), suspended in the air, containing the bacteria. Any water system, with the right environmental conditions, could be a source for legionella bacteria growth. There is a reasonably foreseeable legionella risk if your water system:

- Has a water temperature between 20 to 45C?
- Creates and/or spreads breathable droplets, e.g. aerosol created by a cooling tower, or water outlets.
- Stores and/or re-circulates water.
- Likely to contain a source of nutrients for the organism to grow, e.g. rust, sludge, scale, organic matter, and bio films.

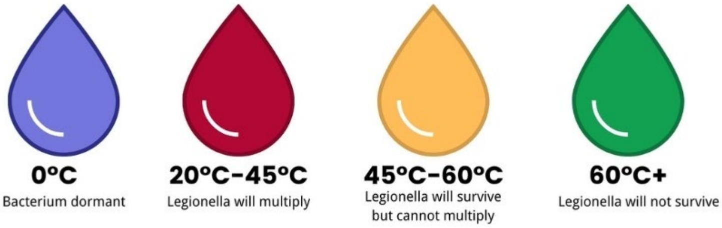
The most common sources of Legionella are in man-made water systems including:

- Cooling tower and evaporative condensers
- Hot and cold-water systems
- Spa pools

There are also several other potential risk systems that may pose a risk to exposure to legionella, including humidifiers, air washers, emergency showers, and indoor ornamental fountains. Particularly also for water systems which are not used on a regular basis and can have a build up of stagnant water, for example infrequently used fire hoses.

Control the Risk from Legionella

The primary method used to control the risk from Legionella is water temperature control. This mainly involves keeping water either cooled below 20C or heated above 60C.



Stagnant water favours Legionella growth. To reduce the risk, you should remove dead legs or dead ends in pipework, flush out infrequently used outlets (including showerheads and taps) at least weekly and clean and de-scale shower heads and hoses at least quarterly.

Cold-water storage tanks should be cleaned periodically, and water should be drained from hot water cylinders to check for debris or signs of corrosion.

Other methods to control Legionella include copper and silver ionisation and biocide treatments (e.g. chlorine dioxide).

Water samples should be analysed for Legionella periodically to demonstrate that bacteria counts are acceptable.

Most organisations use reputable companies to assist with the management of legionella within their premises.

Leptospira

Leptospirosis an infectious bacterial disease occurring in rodents, dogs, and other mammals, which can be transmitted to humans. There are two types:

- Weil's disease: This is a serious and sometimes fatal infection that is transmitted to humans by contact with urine from infected rats.
- The Hardjo form of leptospirosis: This is transmitted from cattle to humans

The bacteria can get into your body through cuts and scratches and through the lining of the mouth, throat, and eyes after contact with infected urine or contaminated water, such as in sewers, ditches, ponds, and slow-flowing rivers.

People working in dairy parlours are often in contact with cattle urine. Rat urine may contaminate animal feed on farms.

Symptoms and Effects, and Persons at Risk

Both diseases start with a flu-like illness with a persistent and severe headache, which can lead to vomiting and muscle pains and ultimately to jaundice, meningitis, and kidney failure. In rare cases, the diseases can be fatal.

Anyone who is exposed to rats, rat, or cattle urine, or to foetal fluids from cattle is at risk. Farmers are now the main group at risk for both Weil's disease and cattle leptospirosis. The cattle form is a special risk for dairy farmers.

Other people who have contracted leptospirosis in recent years include vets, meat inspectors, butchers, abattoir, and sewer workers.

Workers in contact with canal and river water are also at risk.

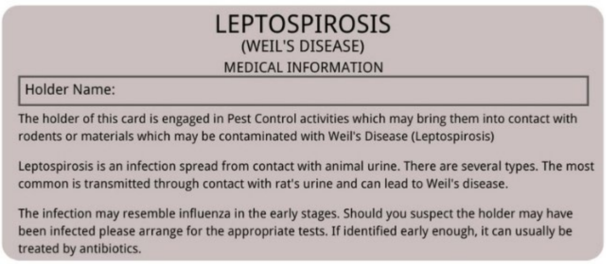
Control the Risk from Leptospira

Prevention strategies of human leptospirosis include wearing protective clothing for people at occupational risk and avoidance of swimming in water that may be contaminated.

Leptospirosis control in animals is dependent on the species of bacteria and animal species but may be either vaccination, a testing a culling programme, rodent control, or a combination of these strategies.

In addition, cuts and grazes should be covered, and hands washed after handling any animal, or any contaminated clothing or other materials and always before eating, drinking, or smoking.

In the UK, the Pest Control Association require workers who are likely to be exposed to Leptospira to carry a card to advise doctors/physicians of possible exposures.


LEPTOSPIROSIS
(WEIL'S DISEASE)
MEDICAL INFORMATION

Holder Name:

The holder of this card is engaged in Pest Control activities which may bring them into contact with rodents or materials which may be contaminated with Weil's Disease (Leptospirosis)

Leptospirosis is an infection spread from contact with animal urine. There are several types. The most common is transmitted through contact with rat's urine and can lead to Weil's disease.

The infection may resemble influenza in the early stages. Should you suspect the holder may have been infected please arrange for the appropriate tests. If identified early enough, it can usually be treated by antibiotics.

Norovirus

Norovirus, sometimes known as "winter vomiting bug" in the UK (although it can be caught at any time of the year), is the most common cause of viral gastroenteritis in humans. It affects people of all ages.

The virus is transmitted by faecally contaminated food or water, by person-to-person contact, and via aerosolisation of vomited virus and subsequent contamination of surfaces.

The virus affects around 267 million people and causes over 200,000 deaths each year. These deaths are usually in less developed countries and in the very young, elderly, and immunosuppressed (the body's immune system intentionally stopped from working).

While anyone can become infected, young children and older people are at a higher risk of dehydration than others from failure to retain fluids.

In the workplace, those at greater risk include workers in:

- Health care facilities
- Schools, nurseries, and childcare centres
- Food establishments

Symptoms and Actions

The symptoms of norovirus are very distinctive. You are likely to have norovirus if you experience:

- Suddenly feeling sick
- Projectile vomiting
- Watery diarrhoea

Some people also have a slight fever, headaches, painful stomach cramps, and aching limbs.

The symptoms appear one to two days after you become infected and typically last for up to two or three days.

Preventing Norovirus

Key measures for containing and minimising the risk of an outbreak of norovirus include:

- Ensure communal areas such as kitchens and washroom facilities are regularly cleaned.
- In the event of an outbreak, commission a deep clean of the workplace.
- Promote good hygiene standards. Encourage staff to regularly wash their hands
- Always make sure good quality hand sanitizers are available.
- Ask staff who contract the virus to stay away from work for at least 48 hours after the symptoms have disappeared to avoid contaminating work colleagues.

Tips for workers to prevent them from catching norovirus include:

- Wash your hands often throughout the day, especially after using the toilet and before preparing or eating food.
- Avoid using items such as tea towels or towels, which are normally present in communal areas and used by lots of people. These items can house high levels of bacteria.
- Alternatively, encourage your employer to provide hand towel dispensers and lidded waste receptacles.
- Clean your desk regularly. Ensure all surfaces are thoroughly cleaned if you eat at your desk and make sure that all food is removed and stored in the kitchen area when you have finished eating.
- Prevent the virus spreading by staying away from work if you suspect you have symptoms, which include headaches and vomiting, and do not return until 48 hours after the last symptoms have disappeared.

General control measures for exposure to biological agents

Elimination of the biological source should be the first consideration. However, this is not always possible. Dependent on the activity, exposure prevention and control measures might include:

- Engineering controls such as improvement of ventilation, such as installation of negative pressure and separate ventilation and air-conditioning systems (For example in medical wards for infectious diseases)
- Sterilisation (such as the use of ultraviolet lamps can help contain the spread of bio-agents).
- The use of suitable respiratory protection and personal protective equipment, such as face masks and shields; aprons/coveralls; gloves and shoe coverings.
- Good housekeeping and cleaning regime.
- Good personal hygiene standards, such as regular washing of hands with soapy water.

- Proper disposal of contaminated waste (for example, sharps/syringes).
- Immunisation programmes as appropriate.

Other task-related control measures include:

- Design and use of appropriate systems or engineering controls: For example, within Sewage work this include the use of remote cameras for sewage inspections.
- Control risks at source: For example using a Microbiological Safety Cabinet where work could create an infectious aerosol in a laboratory
- Substitute the hazard: Quality control/quality assurance work associated with a screening programme for a toxin-producing food-borne agent such as E. coli O157 can easily be carried out using non-toxin-producing strains. Such strains are readily available from culture collections or else as part of commercially available testing kits

The provision of PPE should always be considered as a last resort once all other avenues have been exhausted.

9.11: Noise

The basic concepts of sound

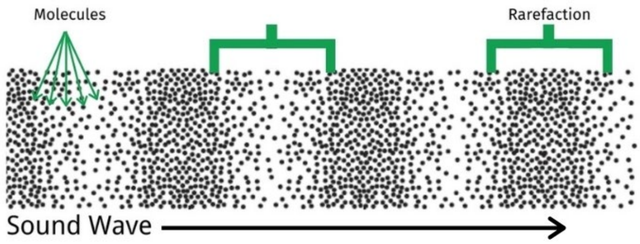
Introduction

Very simply, sound is the vibration of any substance. The substance can be air, water, wood, or any other material, and in fact, the only place in which sound cannot travel is in a vacuum.

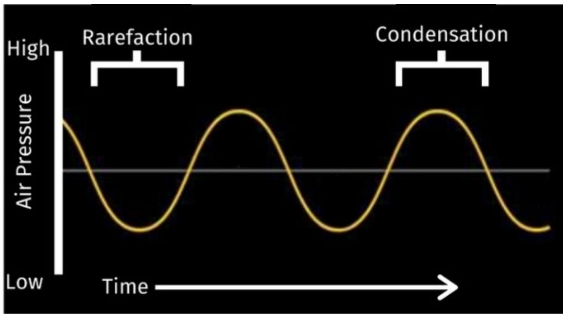
When these substances vibrate, or rapidly move back and forth, they move the air, producing sound. Our ears detect these vibrations and allow us to interpret them.

To be a little more accurate in our definition of sound, however, we must realise that the vibrations that produce sound are not the result of an entire volume moving back and forth at once. If that were the case, the entire atmosphere would need to shift for any sound to be made at all! Instead, the vibrations occur among the individual molecules of the substance, and the vibrations move through the substance in longitudinal sound waves.

As sound waves travel through the material, each molecule hits another and returns to its original position. The result is that regions of the medium become alternately denser, when they are called condensations (or compressions), and less dense, when they are called rarefactions.



Sound waves are often depicted in graphs like the that follows, where the x-axis is time, and the y-axis is pressure or the density of the medium through which the sound is travelling.



Frequency

Every cycle of sound has one condensation, a region of increased pressure, and one rarefaction, a region where air pressure is slightly less than normal.

The frequency (or period) of a sound wave is measured in hertz, named after the German physicist Heinrich Hertz (1857-1894).

Hertz (Hz) indicate the number of cycles per second that pass a given location.

A higher pitched sound has a higher frequency than a lower pitched sound.

Wavelength:
Horizontal length of one cycle of a wave

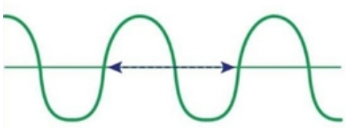


Figure 1: Cycle of a wave

Period:
The time required for one wavelength to pass a certain point. Generally, a longer period indicates a lower pitch.

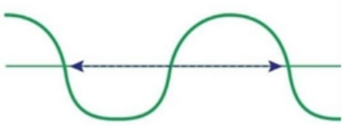


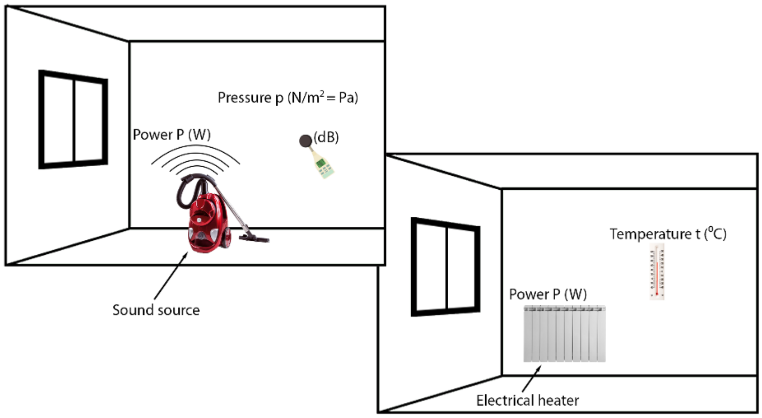
Figure 2: A longer period indicates a Lower Pitch

Sound Pressure and Sound Intensity

Before describing the physical properties of sound, let's make an analogy between sound, and a maybe better-known physical phenomenon: heat.

An electrical heater produces a certain amount of energy per unit time [Joule/sec] i.e. it has a certain power rating in Watts [Watt = Joule/sec]. This is a basic measure of how much heat it can produce and is independent of the surroundings. The energy flows away from the heater raising the temperature in other parts of the room and this temperature can then be measured with a simple thermometer in ºC or ºF.

However, the temperature at a point will not only depend on the power rating of the heater and the distance from the heater, but also on the amount of heat absorbed by the walls, and the amount of heat transferred through the walls and windows to the surroundings.



A sound source will produce a certain amount of sound energy per unit time [Joule/sec], i.e. it has a certain sound power rating in W [Watt = Joule/sec]. This is a basic measure of how much acoustical energy it can produce and is independent of its surroundings. The sound energy flows away from the source giving rise to a certain sound pressure in the room.

When the sound pressure is measured, this will not only depend on the power rating of the source and the distance between the source and the measurement point, but also on the amount of sound energy absorbed by the walls and the amount of sound energy transferred through the walls and windows to the surroundings.

Sound intensity describes the rate of flow of sound energy. High-intensity sound has more energy than low-intensity sound. Intensity is measured in watts per square metre (W/m2).

Sound pressure is the local pressure deviation from the ambient atmospheric pressure, caused by a sound wave. It is measured in Pascals.

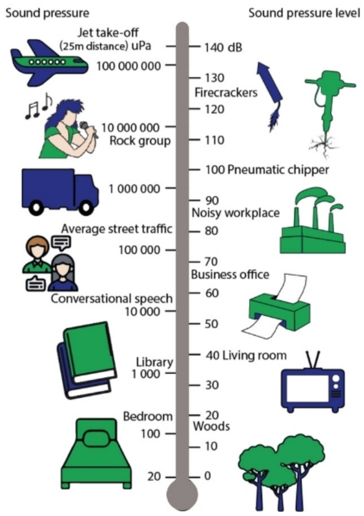
For reasons mentioned later, the Decibel (not the Pascal) is the unit used for sound pressure level measurement.

The Decibel scale

When a sound source such as a tuning fork vibrates it sets up pressure variations in the surrounding air. The emission of the pressure variations can be compared to the ripples in a pond caused by a stone thrown in the water. The ripples spread out from the point where the stone entered. However the water itself does not move away from the centre. The water stays where it is, moving up and down to produce the circular ripples on the surface.

Sound is like this. The stone is the source, the pond is the air, and the ripples are the resulting sound wave.

Compared with the static air pressure the audible sound pressure variations are very small, ranging from about 20 µPa (10 to the power of -6 Pa) to 100 Pa. 20 µPa is the quietest sound that can be heard by an average person and it is therefore called the threshold of hearing (normal breathing is just above the threshold of hearing). A sound pressure of approximately 100 Pa is so loud that it causes pain, and it is therefore called the threshold of pain (such as a jet aircraft taking off). The ratio between these two extremes is more than a million to one.

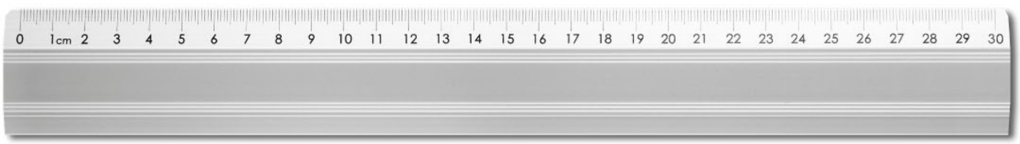


Pascals (Pa)- Decibels (dB)

The direct application of linear scales, in Pa, to the measurement of sound pressure would therefore lead to the use of enormous and unwieldy numbers. Additionally, the ear responds not linearly but logarithmically to stimulus. For these reasons, it has been found more practical to express acoustic parameters as a logarithmic ratio of the measured value to a reference value - a logarithmic ratio called a decibel or just dB (dB is the measurement of sound pressure level).

The advantage of using dB's is clearly seen when a dB scale is drawn as on the illustration shown earlier. The linear scale with its large and unwieldy numbers is converted into a much more manageable scale from 0 dB at the threshold of hearing (20 µPa) to 130 dB at the threshold of pain.

Think of a linear scale as a tape measure: going 10 units up the scale gets you 10 units more than where you started. If you start at zero centimetres and add 10, you're at 10 centimetres; start at 10 centimetres, add 10 more, and you're at 20 centimetres. Easy enough, right? However, a logarithmic scale is very different. Here, going 10 units up the scale increases the previous number by a factor of 10, not by 10 units.



To see what this looks like, we need to know where we're starting. Zero on the decibel scale is the "threshold of human hearing": it's the least intense sound a human can detect. Just note how quickly the logarithmic scale of decibels goes up from there:

- 0 dB threshold of human hearing
- 10 dB 10 times more intense (10 to the power of 1)
- 20 dB 100 times more intense (10 to the power of 2)
- 30 dB 1,000 times more intense (10 to the power of 3)
- 40 dB 10,000 times more intense (10 to the power of 4)

Basically, for every 10 dB increase, we're adding a zero to the amount of intensity versus the threshold of hearing. So, a sound that's 120 dB—a jet engine, for example—is one trillion times (10 to the power of 12) the intensity of the smallest sound a human can hear.

In practical terms, it is useful to remember (because of this logarithmic relationship) that increasing a sound level by 3dB (e.g. 87 to 90) DOUBLES the sound intensity!

Weighting scales

The human ear can detect sound over a range of frequencies, typically from 20Hz to 20,000Hz. However, you will often see noise levels given in dB (A-weighted sound levels) instead of dB.

Measurements in dBA, or dB(A) as it is sometimes written, are decibel scale readings that have been adjusted to attempt to consider the varying sensitivity of the human ear to different frequencies of sound. The main effect of the adjustment is that low and very high frequencies are given less weight than on the standard decibel scale.

Many regulatory noise limits are specified in terms of dB(A), based on the belief that dB(A) is better correlated with the relative risk of noise-induced hearing loss.

Compared with dB, A-weighted measurements underestimate the perceived loudness, annoyance factor, and stress-inducing capability of noises with low frequency components, especially at moderate and high volumes of noise.

Another system of adjustment is C-weighting, the dB(C) scale. This is a standard frequency weighting for sound level meters, commonly used for higher level measurements and Peak - Sound Pressure Levels.

The Concept of Equivalent Noise dose

ILO Convention R156 - Working Environment (Air Pollution, Noise and Vibration) Recommendation, 1977 lays down the general requirements for the protection of workers from occupational noise exposure. The detail is laid out in ILO Code of Practice " Protection of workers against noise and vibration in the working environment".

In particular, the Code of Practice lays down maximum exposure limits as follows:

- **warning limit:** 85dB(A) (continuous exposure)
- **danger limit:** 90dB (A) (continuous exposure)
- **peak limit:** 140dB

Equivalent continuous sound pressure level (LAeq)

The LAeq is defined as " when a noise varies over time, the LAeq is the equivalent continuous sound which would contain the same sound energy as the time varying sound the measurement of sound" (think of it as a type of average, where noisy events in a period have a significant influence.)

Daily Personal Exposure Level (LEP,d)

The LEP,d is a worker's daily exposure to noise at work (normalised to an 8-hour day), considering the average levels of noise and the time spent in each area. This is the parameter that is generally used by national legislation (such as the UK Noise at Work Regulations) and is essential in assessing a worker's exposure and what action should be taken.

Personal noise exposure may also be calculated over a week rather than a day, if the noise exposure of workers varies markedly from day to day. This is written as LEP,w.

Peak sound pressure level (LCpeak)

Is a measure of the maximum instantaneous sound pressure at a specified location. Exposure to high peak sound levels can be associated with immediate damage to hearing.

The ILO Code of practice specifies a peak sound pressure of 140dB - above which employees must not be exposed.

The physical and psychological effects on the individual

Physical Effects of Noise

Noise in the workplace is recognised as a risk factor for hearing loss for those exposed to sudden, extreme, levels and those exposed to moderately high levels over extended periods of time.

The effects may be acute or chronic.

Acute Effects of Noise

Acoustic Trauma:

Acoustic trauma can be caused by a sudden and powerful sound like an explosion. Such sudden, extreme levels of noise often lead to damaged ear drums and consequently conductive hearing loss.

Temporary Threshold Shift:

Caused by short exposures to excessive noise (for example, attending a loud rock concert). In such cases, the sensory hairs (cilia) of the cochlea "go to sleep". This means that the person temporarily experiences reduced hearing. After removal from exposure to the noise and rest, the hairs recover, and normal hearing is restored.

Temporary Tinnitus:

This is a "ringing" in the ears caused by exposure to high noise levels. It results in over stimulation of the cochlea hairs and usually stops some 24 hours after exposure ceases.

Chronic Effects of Noise

Noise Induced Hearing Loss (NIHL):

Arises from the permanent damage to the cochlea hair cells, as a result of sustained exposures to high levels of noise. The cells that are damaged first are those at 4000Hz, the frequency of speech. Over time, sounds may become distorted or muffled, resulting in difficulties in understanding other people when they talk or having to turn up the volume on the television.

Permanent Threshold Shift:

This is a permanent shift in the auditory threshold (loss of hearing). It can arise because of exposure to high levels of noise, but also because of age, infections, or disease. The difference with NIHL is that NIHL effects hearing only at certain frequencies. Permanent Threshold Shift affects all frequencies.

Presbycusis is a term that is used for hearing loss with age whereby, as we get older, hearing loss is across all frequencies. It is possible to tell the difference between age related and noise induced hearing loss, using audiometric testing.

Permanent Tinnitus:

This is the same as the acute form but becomes permanent.

The Psychological Effects of Noise

Reported non-auditory effects of noise include increased stress, cardiovascular function (hypertension, changes in blood pressure and/or heart rate), annoyance, sleeping problems, and mental health issues. This wide range of effects has led researchers to believe that noise can act as a general, non-specific, stressor.

Examples of temporary physiological effects are:

- The startling response to loud noise, where muscles burst into activities, generally, with the intention to protect (fight or flight response).
- The muscle tension response, where muscles tend to contract in the presence of loud noise.
- The respiratory reflexes, where the respiratory rhythm tends to change when noise is present.
- Changes in the heartbeat pattern.
- Changes in the diameter of the blood vessels, particularly in the skin.

All these effects are like the response of the body to other stressors.

Noise risk assessment and planning for control

Introduction

The first thing to do is to decide whether or not there is a noise problem in the workplace. As a simple guide, something will need to be done if any of the following apply:

- Is the noise intrusive - like a busy street, a vacuum cleaner or a crowded restaurant - for most of the working day?
- Do your employees have to raise their voices to carry out a normal conversation when about 2 m apart for at least part of the day?
- Do your workers use noisy powered tools or machinery for more than half an hour each day?
- Do you work in a noisy industry, e.g. construction, demolition or road repair; woodworking; plastics processing; engineering; textile manufacture; general fabrication; forging, pressing or stamping; paper or board making; canning or bottling; foundries?
- Are there noises due to impacts (such as hammering, drop forging, pneumatic impact tools, etc.), explosive sources such as cartridge operated tools or detonators, or guns?

If the answer is 'yes' to any of the above questions you will need to assess the risks to decide whether any further action is needed, and plan how you will do it.

Some examples of typical noise levels are shown in the figure that follows.

Image source - https://www.hse.gov.uk/noise/advice.htm

The aim of the risk assessment is to help you decide what you need to do to ensure the health and safety of your employees who are exposed to noise. It is more than just taking measurements of noise - sometimes measurements may not even be necessary.

The risk assessment should:

- Identify where there may be a risk from noise and who is likely to be affected.
- Contain a reliable estimate of your workers' exposures and compare the exposure with legal limits.
- Identify what you need to do to comply with any national law, e.g. whether noise-control measures or hearing protection are needed, and, if so, where and what type
- Identify any workers who need to be provided with health surveillance and whether any are at particular risk.

Competence

Employers need to make sure that the risk assessment:

- Has been drawn up by someone who is competent to carry out the task
- Is based on advice and information from people who are competent to provide it.

Organisations may well have people who are competent in some or all areas. They may, however, choose or need to go to external noise consultants.

Estimating worker exposure

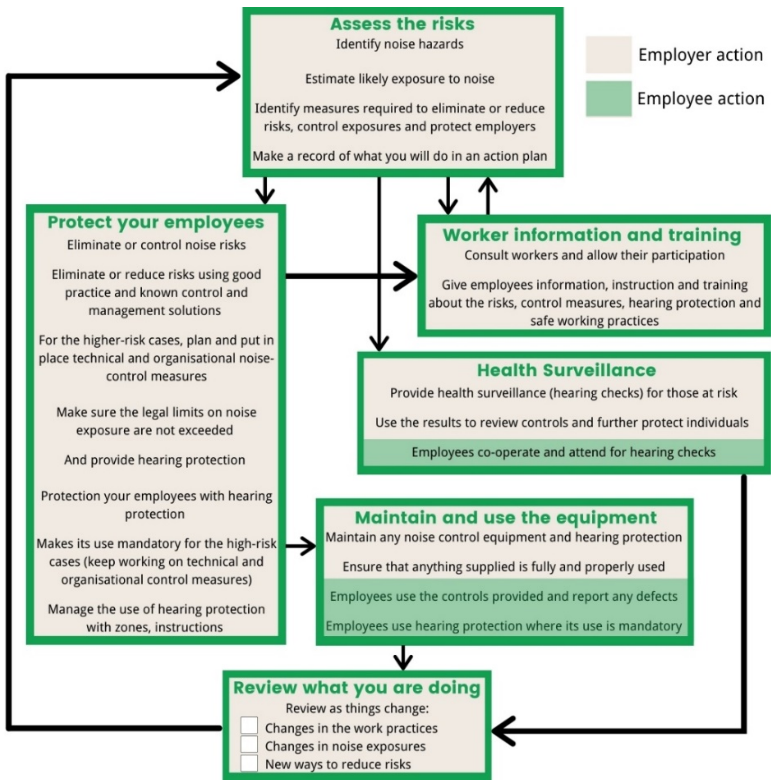
It is essential that you can show that your estimate of workers' exposure is representative of the work that they do. It needs to take account of:

- The work they do or are likely to do
- The noise sources that they might be exposed to
- Noise emission levels from equipment used or in the area
- Times of exposure
- The ways in which they do the work
- How it might vary from one day to the next

The estimate must be based on reliable information, e.g. measurements in your own workplace, information from other workplaces similar to yours, or data from suppliers of machinery.

You must record the findings of your risk assessment. You need to record in an action plan anything you identify as being necessary to comply with national law, setting out what you have done and what you are going to do, with a timetable and saying who will be responsible for the work.

Review your risk assessment if circumstances in your workplace change and affect noise exposures. Also review it regularly to make sure that you continue to do all that is reasonably practicable to control the noise risks. Even if it appears that nothing has changed, you should not leave it for more than about two years without checking whether a review is needed.



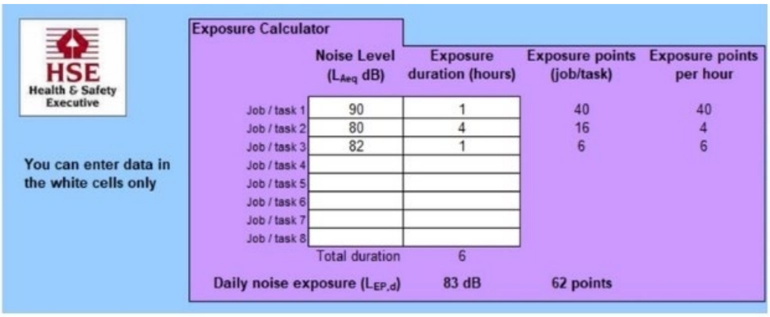
The use of noise calculators to determine mixed exposures

In order to demonstrate compliance with any laid down exposure levels in national legislation on noise, it is necessary to monitor and measure personal exposures. This can be done in a number of ways, including:

- Manual calculation.
- Exposure calculators (such as the UK HSE calculators for daily or weekly noise exposure calculators).

Example 1 Using UK HSE exposure calculator

A man works as a process operator. Typically, he spends a total of 1 hour per shift looking after air compressors where the average LAeq is 90 dB. For another 4 hours per night he does administrative tasks in a plant office where the LAeq is 80 dB and another 1 hour topping up machinery with oil in a pump house where the LAeq is 82 dB.



	Noise Level (L_{Aeq} dB)	Exposure duration (hours)	Exposure points (job/task)	Exposure points per hour
Job / task 1	90	1	40	40
Job / task 2	80	4	16	4
Job / task 3	82	1	6	6
Job / task 4				
Job / task 5				
Job / task 6				
Job / task 7				
Job / task 8				
	Total duration	6		
Daily noise exposure ($L_{EP,d}$)		83 dB	62 points	

Image source - https://www.hse.gov.uk/vibration/hav/roadshow/al7.pdf

HSE Exposure Calculator

After we enter the noise levels and exposure hours, we can see that the workers daily exposure level (LEP,d) is 83 dB

Whilst using a calculator is not absolutely precise if we have collected reasonably accurate noise measurements and time of exposure, we can calculate an approximate daily noise exposure. This is often sufficient for the purposes of noise risk assessment. It is especially useful for those organisations who do not have the financial resources to use specialist noise consultants.

Comparison with Legal Limits

Once the workers' personal noise exposure has been calculated, it is necessary to compare this to a standard to determine whether the exposure is acceptable or not. Many countries have established legal limits on noise exposure. In the UK, there are several limits and action values.

- Once the exposure reaches 80dB over an 8-hour period (or a peak level of 135dB(C)), hearing protection is advised (but not mandatory). This is called the lower action value.
- Once the exposure reaches 85dB or above over an 8-hour period (or reaches a peak level of 137dB(C)), hearing protection becomes mandatory, and the employer must take other action to reduce noise levels at source. This is called the upper action limit.
- When the 8-hour time weighted average reaches 87dB, or a peak sound pressure of 140dB(C) is achieved, then the employer must take immediate action to reduce noise exposure levels.

The USA operates a similar system of limits and action values. The 8-hour time weighted average in the USA is 90dB.

The hierarchy of noise control

Introduction

Wherever there is a noise issue in a workplace, organisations should be looking for alternative processes, equipment and/or working methods which would make the work quieter or mean people are exposed for shorter times. They should also keep up with what is good practice or the standard for noise-control within that industry, e.g. through your trade association, or machinery or equipment suppliers.

There is a hierarchy of control measures that can be followed to ensure the health and safety of workers:

- Eliminate or control the noise at source (preferred, most effective, and cheapest in the long-term).
- Control the noise along its transmission path.
- Control noise at the receiver (least effective, hardest to manage, and more expensive in the long-term).

Elimination or Control of the Source

Purchasing Procedures

When hiring, buying, or replacing equipment, you should consider noise alongside other factors (e.g. general suitability, efficiency). Compare the noise data from different machines as this will help you to buy from among the quieter ones. The manufacturers should be able to provide noise data for their equipment. For this reason, it is important for H&S professionals to introduce Purchasing Procedures that require the organisation to consider the levels of noise from equipment, and not just purchase based on the price.

Substitution

Ask whether it is cost effective to replace a piece of equipment with a quieter one. If not, it may be possible to replace certain components with quieter versions. For example:

- Replacing metal gears with nylon gears.
- Replacing rigid pipework with flexible pipework which absorbs vibration.

Maintenance

A common cause of noise is ageing and poorly maintained equipment. This creates vibration and friction, which in turn create noise. One option is to replace old equipment. Another is to maintain it regularly to keep it in good working order. Belts and drives can be tightened or replaced. Gears can be lubricated. Whilst the benefits of replacing or maintaining one item of equipment is not immediately obvious, workers are exposed to the noise of many items of equipment. If the noise levels generated by each are slightly reduced, the cumulative benefits are significant.

Workplace Layout and Increasing Distance

Noisy machines or activities can be moved and located further away from workers. Distance creates a natural barrier. Every time the distance between people and the noise source is doubled, the levels of noise reaching the people are reducing by a factor of four. This is something known as the ‘inverse-square’ law.

Equipment can be relocated away from workers, preferably outside of the working area. For example, noisy plant such as motors and pumps can be housed in external sheds or buildings. Not only does the distance reduce the noise

exposure of workers, but the walls of the structures can be designed to absorb the noise vibrations, reducing noise transmission even further.

Machine design

Existing machines and processes can be redesigned to generate less noise. Changes to the design of machines are likely to require some specialist advice from noise control engineers. The below figures are examples of how simple design changes can reduce machinery noise levels.

Job Design

Noisy devices should only be used when they are needed. For example, the pneumatic ejector on a power press need be on only for the short time required to eject the product. The air supply should be ‘pulsed’ to operate only when the product needs removing. Similarly, local exhaust ventilation should be turned off when the extraction is not needed.

Different ways of working

Changes in technology can alter the machine or process, resulting in a lower noise exposure to the workforce. Sometimes a different way of working might avoid the need for a noisy operation. Examples of quieter processes, machines, and activities include:

- Use welded or bolted construction instead of riveted construction in large-scale fabrications.
- Replace noisy compressed-air tools with hydraulic alternatives.
- Improve the quality of manufacturing to avoid later rework with potentially noisy processes, e.g. more accurate cutting of steel plate may eliminate noisy reworking with grinders or air chisels.

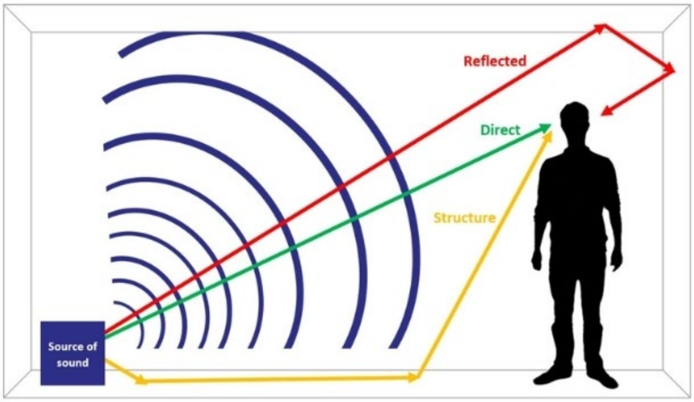
Controlling the Transmission of Noise - Behaviour of Noise at Interfaces

Noise travels via several paths towards the receiver. It can travel through the air, or through materials and structures. Depending on the surface the sound impacts, the sound will behave in different ways.

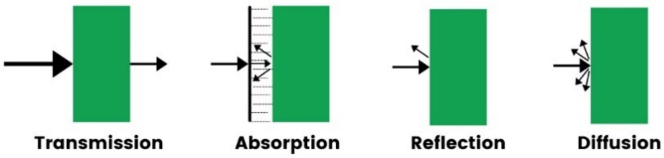
When travelling through a path, the noise will either:

- Be transmitted. In other words, the material the noise is travelling through aids the transmission of noise. For example, vibrations through a wall or material which themselves transmit the noise. In the figure that follows, this is shown by the green arrow.
- Be reflected. Noise travels through the air in pressure waves. These waves can ‘bounce’ off a surface and travel back or in another direction. For example, noise can reverberate around a large hall. In the figure below, this is shown by the red arrow.

- Be absorbed. Noise can be absorbed by a material. The material will absorb some or all the vibrations, stopping the transmission of noise.



It is important to understand how noise interacts with surfaces because this will help us decide on appropriate ways of reducing the transmission of noise.



Sound Reduction Indices and Absorption Coefficients

All building materials have some acoustical properties in that they will all absorb, reflect, or transmit sound striking them. Conventionally speaking, acoustic materials are those materials designed and used for absorbing sound that might otherwise be reflected (examples include polyurethane foams and fibreglass).

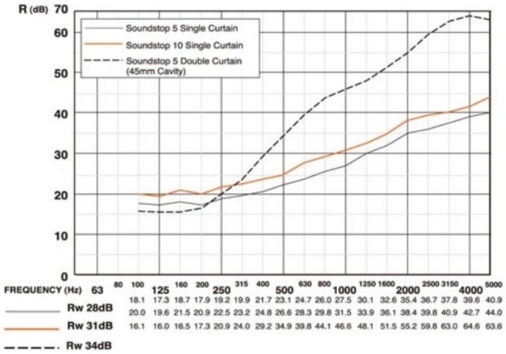
Sound absorption is where the sound that strikes a material is not reflected back. An open window is an excellent absorber since the sounds passing through the open window are not reflected back but makes a poor sound barrier. People outside the window will hear the sound. A painted concrete block is a good sound barrier but will reflect about 97% of the sound striking it.

When a sound wave strikes an acoustic material the sound wave causes the fibres or particle makeup of the absorbing material to vibrate. This vibration causes tiny amounts of heat due to the friction and thus sound absorption is accomplished by way of converting the sound waves to heat. The more fibrous a material is the better the absorption.

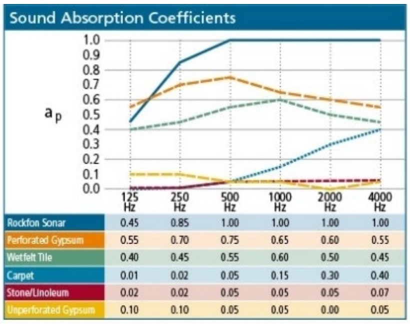
Conversely, denser materials are less absorbent. The sound absorbing characteristics of acoustic materials vary significantly with frequency. In general, low-frequency sounds are very difficult to absorb because of their long wavelength. On the other hand, we are less susceptible to low-frequency sounds, which can be to our benefit in many cases.

For most conventional acoustic materials, the material thickness has the greatest impact on the material's sound absorbing qualities. While the inherent composition of the acoustic material determines the material's acoustic performance, other factors can be brought to bear to improve or influence the acoustic performance. Incorporating an air space behind an acoustic ceiling or wall panel often serves to improve low-frequency performance.

The amount of sound reduction of a material is determined by its sound reduction index (SRI). SRIs are a set of values measured by a specific test method (in a stated frequency band) to determine the amount of sound that will be stopped by the material. The graph that follows shows examples of sound reduction for three types of curtains in the graph below. The greater reductions are in the higher frequencies. Clearly, when selecting materials frequency analysis of the noise, not just the noise level itself, is critical.



Another factor to consider when selecting absorption material is its **sound absorption coefficient** (see graph that follows). Sound absorption is measured using the sound absorption coefficient alpha (α), which has a value between 0 and 1.00. Zero represents no absorption (total reflection), and 1.00 represents total absorption of the incident sound.



The above graph shows that Rockfon sonar totally absorbs noise between 500 Hz and 4000Hz, whilst unperforated gypsum almost totally reflects it.

As you can see from the above coefficients, the materials perform differently depending on the frequency of the noise. It is for this reason that we must consider the frequency (in Hertz) and select our materials accordingly.

When considering using noise-absorbing materials to change the acoustic characteristics of a work area remember:

- Environmental and workplace factors: absorption materials are available in forms which are designed to withstand physical impacts, and can be adapted to hygienic environments, or where absorption of oil, water, etc. may be a problem.
- There may be a reduction in the natural light if absorption is placed on the roof.
- Adding absorbent materials to walls and ceiling areas will only affect the reflected, reverberant sound - not the direct path of sound.

Damping

Damping is adding material to equipment or components to reduce their vibration. Machines can rattle, vibrate, and 'ring' when they are in use. For example, stiff and inflexible panels can vibrate, and circular saw blades can ring when spinning. Metal guards or the sides of equipment are prone to vibrating, and these both generate noise and can transmit noise to other components.

There are various methods of damping:

- Sheets of damping materials such as laminated plastics or rubber can be added to reduce the vibrations.
- The panels can be stiffened further by adding strengthening components, such as ribs
- Some metals have a natural high-damping capacity, such as sound-deadened steel, and this can be used in the initial design and construction of the machine.
- Damping plates can be added to panels, which reduce the transmission of vibration into the panel.
- Circular saw blades can be designed with anti-vibration measures, such as a damping layer across the centre, or holes in the blade strategically positioned to stop the transmission of vibration.

Image source - https://www.hse.gov.uk/noise/casestudies/soundsolutions/heavyplates.htm

Damping can also be applied to reduce the impact of falling objects. The impact creates noise. If the impact can be softened, this will reduce noise at source. In the below example, the conveyor is dropping stones into a hopper. The conveyor can be repositioned to reduce the drop height. This reduces the velocity of the stones when they impact the hopper. Furthermore, a heavy duty and abrasion resistant skin have been applied to the interior of the hopper to cushion the impact even more.

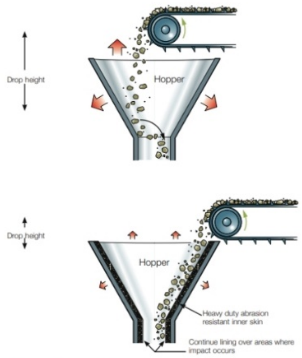


Figure 7 Reduced drop heights and cushioned impacts reduce noise

Image source - https://www.hse.gov.uk/pubns/priced/l108.pdf

Vibration will travel through materials. Vibrations from machinery can travel into the floor and cause the floor to vibrate and make noise. This can be a significant problem if the floor is flexible, such as a wooden or metal mezzanine floor.

One solution is to separate the machinery from its surroundings and its supports. Fixed equipment can be mounted on anti-vibration mounts or feet, usually made from rubber or springs. This is referred to as isolation.

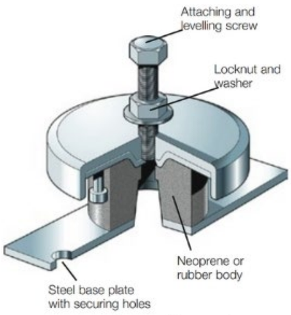
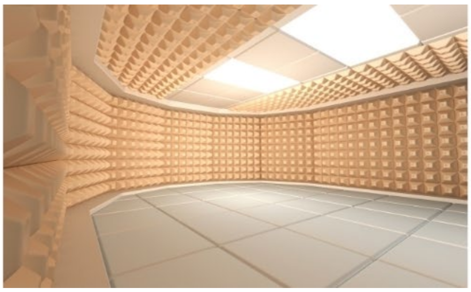


Image source - https://www.hse.gov.uk/pubns/priced/l108.pdf

When noise hits a hard, flat, surface it is reflected, and the energy remains intact. The result is an echo. Noise diffusion is the scattering of sound wave energy in many directions, over a wide area. This reduces the amount of sound energy transmitted in any one direction.

Complex surface materials are used to diffuse sound. These contain many surface angles, designed to reflect the sound in many directions. These are fixed to flat surfaces such as walls and ceilings and prevent echoes from reverberating around the room. Many diffusive materials are also highly absorbent, decreasing noise transmission even further.



Screens and Barriers

Screens, barriers, or walls can be placed between the source of the noise and the people (the "pathway") to stop or reduce the direct sound. Barriers should be constructed from a dense material, e.g. brick or sheet steel, although chipboard and plasterboard can be used.

Image source - https://www.hse.gov.uk/pubns/priced/l108.pdf

Screens and barriers work best when they are placed close to the noise source or close to the people who are to be protected. The higher and wider they are, the more effective they are likely to be. Covering the barrier or screen with noise-absorbing material on the side facing the noise source will have the added advantage of reducing the sound reflected back into that area containing the noise source.

Enclosures

Noisy machines can be enclosed fully, or a partial enclosure or an acoustic cover can be placed around a noisy part of a machine. The figure that follows outlines the features required of a typical machine enclosure.

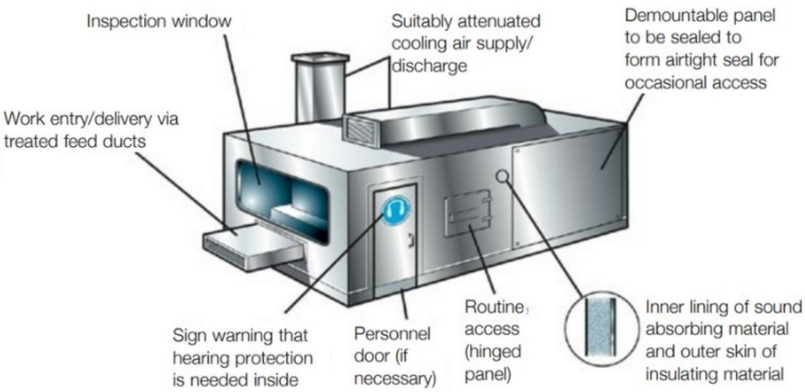
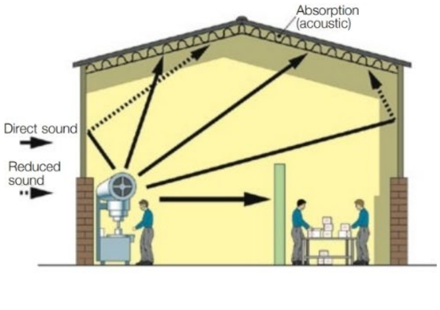


Image source - https://www.hse.gov.uk/pubns/priced/l108.pdf

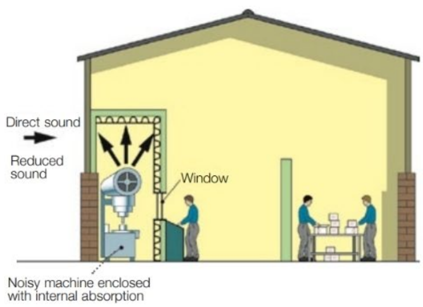
An efficient noise enclosure will provide a good quality dense insulation barrier (such as steel or brick) to stop noise escaping, and sound-absorbing material on the inside (on the walls and the top) to reduce reflections and therefore noise build up in the enclosure. The whole enclosure should be robust enough to withstand the working environment and possibly protected against vehicle impact. Windows should be eliminated but, if essential, these should be double glazed. Good seals should be provided around any openings because small leaks can dramatically reduce the effectiveness of the enclosure. The gaps at the floor should also be sealed. Any pipes or ducting entering the enclosure should be flexible or have flexible connections to create a vibration 'break' (essentially a form of isolation). Doors should be fitted with self-closing devices, and any materials entry and inlets lined with absorbent material. Ventilation points may be required, and if so, these should be provided with acoustic louvres. The machinery itself inside should be dampened wherever possible and mounted on anti-vibration mounts to isolate it from the floor.

Any operating controls for the machinery should be positioned outside. Access to the machine is required for maintenance, so removable access panels or doors should be fitted.

The figures that follow show the principles of barriers and enclosures in practice.



The correct use of absorption in the roof will reduce the reflected noise reaching the quiet area



Segregation of the noisy operation will benefit the whole workplace

Image source - https://www.hse.gov.uk/pubns/priced/l108.pdf

Active Noise Control

Active noise control is an electronically controlled noise-reduction method and involves the reduction or cancellation of one sound by the introduction of a second ‘opposite’ sound.

Sound is a pressure wave in the air, with a frequency (alternating periods of compression and rarefaction). Active noise control emits a sound at the same amplitude, but with the phase of compression and rarefaction inversed. This causes interference in the pressure wave and cancels it out.

The technique is most effective in reducing low-frequency noise. It has been used to control noise in ducted systems such as diesel engine exhausts and the low-frequency rumble from gas turbine stacks. It has also been used to extend the performance of hearing protection and noise-reducing helmets.

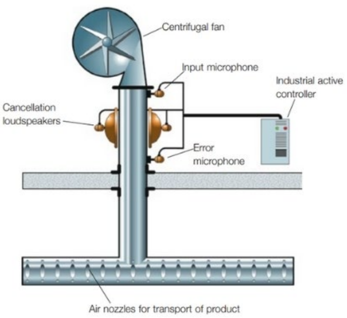


Image source - https://www.hse.gov.uk/pubns/priced/l108.pdf

Controlling Exposure at the Receiver

Acoustic Havens

These can be a practical solution in situations where noise control is very difficult, or where only occasional attendance in noisy areas is necessary.

The design of havens will be similar to that of acoustic enclosures, although since the purpose is to keep noise out rather than in, lining the inner surfaces with acoustic absorbent material will not be necessary. Workers and/or managers will work as much as possible inside the haven.

In practice, havens are often used as offices, control rooms, and rest areas.

A noise refuge and control room

Image source - https://www.hse.gov.uk/pubns/priced/l108.pdf

Hearing Protection Zones

Where the noise risk assessment has identified certain areas as being particularly noisy (usually above 80dB or 85dB), these can be designated as hearing protection zones. These are areas where hearing protection is either optional or mandatory. In a mandatory hearing protection zone, the hearing protection must be worn by all those in the area, regardless of how much time they spend there.

The noise risk assessment will create a map of hearing protection zones. This can be presented to workers and contractors at the induction training, and any subsequent training on noise or hearing protection.

At the entrances of the zone, signage must be displayed to warn people they are entering a hearing protection zone. This can be supported by markings on the floors and on walkways. Disposable ear plug dispensers are usually installed at the entrances near the signage. These need to be regularly replenished.

Types of Hearing Protection

Hearing protectors are available in many forms. They are all capable of providing a reduction in noise exposure and will be provided with information to allow you to decide whether they provide adequate noise reduction for your work situation.

Whichever type of protector is used, it will provide its best protection only if it is in good condition, is the correct size and is worn properly. All hearing protection should carry the appropriate marking to ensure it conforms to a relevant standard (such as CE, ANSI marking).

The following factors should be considered when selecting hearing protection:

- Types of protector, and suitability for the work being carried out
- Noise reduction (attenuation) offered by the protector
- Compatibility with other safety equipment
- The pattern of the noise exposure
- The need to communicate and hear warning sounds
- Environmental factors such as heat, humidity, dust, and dirt
- Cost of maintenance or replacement
- Comfort and user preference
- Medical disorders suffered by the wearer

The types of hearing protection include:

- Ear muffs
  - Standard ear muffs
  - Noise cancelling ear muffs
  - Helmet mounted ear muffs
- Ear plugs.
  - Foam
  - Rubber
  - Disposable
  - Reusable and washable
  - With neck cords
  - With neck bands
  - Custom moulded

Special Types of Hearing Protector

- Level-Dependent Protectors: Level-dependent (or amplitude-sensitive) hearing protectors are designed to protect against hazardous noise while permitting good communication when it is quieter. They are most suited to situations where the noise exposure is intermittent and there is a need to communicate during quieter intervals.
- Flat or tailored frequency response protectors: Whereas most hearing protectors provide greater reduction of noise at high frequencies than they do at low frequencies, this type of protector, by its design, gives a similar reduction across a wide frequency range (i.e. a flat frequency response). This can assist effective communication and can be useful in circumstances where it is important to be able to hear the high-frequency sound at the correct level relative to the low-frequency sounds, e.g. musicians during rehearsal and practising.
- Active noise-reduction protectors: Active noise-reduction (ANR) hearing protectors incorporate an electronic sound cancelling system to achieve additional noise reduction. ANR can be effective at low frequencies (50-500 Hz) where ordinary protectors can be less effective. ANR protectors are usually based on an earmuff type protector.
- Protectors with communication facilities: These devices make use of wired or aerial systems to relay signals, alarms, messages, or entertainment programmes to the wearer. These protectors should be designed so that the level of the relayed signal is not too loud. Where the devices are used to receive spoken messages, the microphone should, where possible, be switched off when not in use, to avoid the reproduction at the ear of spurious background noise.

Hearing protection must be monitored for wear and damage and replaced when necessary. If hearing protectors are to be effective, and provide the expected protection, they must be in good condition. With experience, simple checks can be made by visual inspection and feel. It is good practice to keep a set of new protectors on display, to provide a basis for comparison. Earmuffs need regular maintenance. Over time the seals become less firm and fail to create a good seal around the ear. Also, the headbands can stretch or deform, and no longer apply pressure to each side of the head. The seals need to be checked regularly, and replacements fitted.

Figure 36 Damaged earmuff seal

Figure 37 Damaged helmet-mounted earmuff seal due to prolonged storage in 'up' position

Figure 38 Earmuff headband showing reduced tension (in comparison to tension when new)

Image source - https://www.hse.gov.uk/pubns/priced/l108.pdf

Single Number Rating (SNR) and HML (High, Medium, Low) Methods

SNR is a hearing protector rating number that is used by the European Union and affiliated countries. Tests are conducted at independent testing laboratories. In addition to an overall rating, the SNR further rates protectors in terms of the noise environments in which they will be used - H for high-frequency noise environments, M for mid-frequency, and L for low-frequency.

Note that the HML designation does not refer to the noise level, rather the frequency of the noise. For example, a protector might be designated with SNR 26, H=32, M=23, L=14.

The SNR is limited because it gives one single number: the number of decibels of attenuation across the range of high, medium, and low frequencies. However, it provides no indication of how well it protects against the different frequencies. If the workplace has lots of low-frequency noise and little high-frequency noise, then the SNR will not provide enough data to decide.

The HML assessment method offers a slightly more accurate prediction as it uses a measurement of both 'A' and 'C' weighted sound levels providing some indication of low-frequency noise present. From the example above, "H=32, M=23, L=14", we can expect a reduction in noise exposure of 32dB(A) at the higher frequencies, 23dB(A) at the mid-range frequencies (around 3kHz to 4kHz), and only 14dB(A) at the lower frequencies.

Hearing protection is quite effective at protecting against high and medium frequencies, but less effective at low frequencies.

Using octave band analysis to analyse the frequencies is the first step in selecting appropriate hearing protection. We then refer to the SNR and HML data.

Limiting exposure time
Where some employees do noisy jobs all day, and others do quieter ones, consider introducing job rotation. This might need you to train employees to carry out other jobs. You should be aware that this system will reduce the noise exposure of some employees while increasing that of others, so care and judgement is needed. In addition, employees will need to be rotated away from noisy jobs for a significant proportion of time to make an appreciable difference to their daily exposure. This is because daily exposure is dominated by time in noisy areas.

Health surveillance for noise-induced hearing loss (NIHL) usually means regular hearing checks (audiometric testing) to measure the sensitivity of hearing over a range of sound frequencies. It should include informing employees about the state of their hearing and the keeping of records.

The role of health surveillance

Health surveillance is about putting in place systematic, regular, and appropriate procedures to detect early signs of work-related ill health and acting upon the results. The aims are primarily to safeguard the health of workers (including identifying and protecting individuals at increased risk), but also to check the long-term effectiveness of measures to control risks to health.

Advantages and disadvantages of wearable technologies

The advantages of wearable technologies are that they can track the health of an individual whether that be through noise or vibration monitoring or exposure to radiation by wearing of a personal dosemeter and if needs be alert the user if their exposure levels are too high. This in turn may increase productivity.

The disadvantages are that some workers may see the wearing of technologies as an invasion of privacy and feel that an employer is tracking their everyday movements within the workplace.

9.12: Vibration

Basic Physical Concepts of Vibration

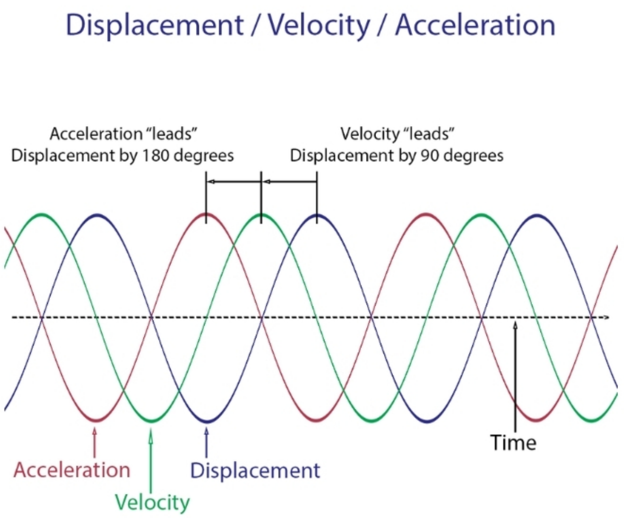
Vibration is the term given to an oscillatory motion involving an object moving back and forth.

During this motion, the object starts from rest to a position of maximum displacement, begins to accelerate towards the equilibrium position from which it has been displaced, overshoots this equilibrium position at its maximum velocity and begins to decelerate due to some restraining force, until it comes to rest at maximum displacement in the opposite direction. The restraining force then begins to propel the object towards the equilibrium position and the process is repeated.

The restraining force then begins to propel the object towards the equilibrium position and the process is repeated.

The following figure shows the change with time, also the relationship between acceleration, velocity, and displacement. In simple terms:

- At the equilibrium position (displacement = 0): velocity is greatest and acceleration zero.
- At maximum displacement: velocity is zero and acceleration is greatest.



Amplitude and Displacement are strongly linked. Displacement is referring to the physical movement of the object, and the distance it travels from its point of rest ('equilibrium') to its point of maximum displacement. When represented in a graph, like the previous figure, the amplitude is the measurement of the change from 0 to its peak.

A complete assessment of exposure to vibration requires the measurement of vibration acceleration (the rate of change of velocity) in metres per second squared (m/s^2). Vibration exposure direction is also important and is measured in well-defined directions or axes. Vibration frequencies and duration of exposure are also determined. How hard a person grips a tool affects the amount of vibrational energy entering the hands. Therefore, hand-grip force is another important factor in the exposure assessment.

The amount of exposure is determined by measuring acceleration in the units of m/s^2.

Most regulating jurisdictions and standard agencies use acceleration as a measure of vibration exposure for the following reasons:

- Several types of instruments are available for measuring acceleration, the rate of change of velocity in speed or direction per unit time (e.g. per second).
- Measuring acceleration can also give information about velocity and amplitude of vibration.
- The degree of harm is related to the magnitude of acceleration.
- Health research data tells us that the degree of harm is related to the magnitude of acceleration.

Vibration Dose(A8)

Vibration Dose is a parameter that combines the magnitude of vibration and the time for which it occurs.

When assessing intermittent vibration, it is necessary to use the vibration dose value (VDV), a cumulative measurement of the vibration level received over an 8-hour period.

In many respects, the concept is very similar to daily noise exposure dose, which is also measured over an 8-hour period.

The EU directive 2002/44/EC specifies the following vibration limits:

Hand arm vibration:

Daily exposure action value (EAV) is 2.5 m/s^2 averaged over 8 hours (A(8) value).

At this point, the employer must begin to act to reduce levels of vibration exposure.

Daily exposure limit value (ELV) is $5m/s^2$ averaged over 8 hours (A(8) value). This must not be exceeded. At this point, the employer must take immediate action to bring the exposure down below the limit (i.e. stop work, condemn the equipment, or introduce job rotation).

Whole body vibration:

Daily exposure action value (EAV) is 0.5 m/s^2 averaged over 8 hours. (A(8) value)

Daily exposure limit value (ELV) is 1.15 m/s^2 averaged over 8 hours. (A(8) value)

Whole body vibration

Groups of workers at risk and health effects:

There is likely to be a risk from WBV where one or more of the following occur:

- Workers regularly drive vehicles off-road.
- The driver/operator is jolted, shaken, or lurches from side to side or backwards and forwards as the machine or vehicle moves or operates.
- Severe shocks and jolts are transmitted into the driver/operator's seat.
- Vehicles have no wheel suspension or have solid tyres.
- The manufacturer of the vehicle/machine warns of WBV risks.
- Vehicles are used for work they were not designed for.
- Vehicle maintenance records suggest that wear and breakages may be due to high levels of vibration or shock.
- Vehicles have damaged seats or seat adjustment mechanisms.
- Replacement suspension seats are unsuitable for the vehicle.
- Vehicles use unmade or poor quality (e.g. potholed) roads for any part of their journey (e.g. delivery to farms, construction sites, depots).
- Vehicles are used on worksites with poor surfaces (cracked, potholed, uneven, or covered in rubble).
- Workers sit or stand on a mobile or static machine when it is operating.
- There is a history of back pain in the job.
- Employees report uncomfortable levels of vibration.
- Employees report pain in their lower back during and after exposure to WBV.

Whole-body vibration (WBV) is transmitted through the seat or feet of employees who drive mobile machines, or other work vehicles, over rough and uneven surfaces as a main part of their job. Large shocks and jolts may cause health risks including back-pain.

Other health effects linked to whole body vibration include fatigue, insomnia, stomach problems, headache, and "shakiness" shortly after or during exposure. Sea, air, or land vehicles cause motion sickness when the vibration exposure occurs in the 0.1 to 0.6 Hz frequency range.

Studies of bus and truck drivers found that occupational exposure to whole-body vibration could have contributed to a number of circulatory, bowel, respiratory, muscular and back disorders. The combined effects of body posture, postural fatigue, dietary habits, and whole-body vibration are the possible causes for these disorders.

Studies show that whole-body vibration can increase heart rate, oxygen uptake and respiratory rate, and can produce changes in blood and urine. East European researchers have noted that exposure to whole-body vibration can produce an overall ill feeling which they call "vibration sickness."

Hand arm vibration

Groups of workers at risk and health effects:

Jobs involving regular and frequent exposure to vibration above the Exposure action value (EAV) are found in a wide range of industries, for example:

- Construction and civil work
- Engineering
- Forestry
- Foundries
- Motor vehicle manufacture and repair
- Maintenance of parks, gardens, verges, grounds, etc
- Shipbuilding and ship repair
- Utilities (e.g. gas, water, telecommunications)

Which tools are most likely to create a risk?

Users of the types of equipment listed below and similar equipment will often be exposed above the EAV:

- Chainsaws.
- Grinders.
- Impact drills.
- Scaling hammers including needle scalers.
- Pedestrian controlled equipment including mowers, floor saws, floor polishers.
- Powered hammers for chipping, demolition, road breaking, etc.
- Sanders and polishers.
- Hand-held saws for concrete, metal, ground clearance, etc.

Damaged and very old models of equipment may be hazardous even when used for very short periods. Most types of hand-held, hand-guided, or hand-fed powered equipment can cause ill health from vibration if used incorrectly.

Regular and frequent exposure to hand-arm vibration can lead to two forms of permanent ill health known as:

- Hand-arm vibration syndrome (HAVS)
- Carpal tunnel syndrome (CTS).

HAVS affects the nerves, blood vessels, muscles and joints of the hand, wrist, and arm, and can become severely disabling if ignored. It includes vibration white finger, which can cause severe pain in the affected fingers.

Symptoms and effects of HAVS include:

- Tingling and numbness in the fingers which can result in an inability to do fine work (for example, assembling small components) or everyday tasks (for example, fastening buttons).

- Loss of strength in the hands which might affect the ability to do work safely.
- The fingers going white (blanching) and becoming red and painful on recovery, reducing ability to work in cold or damp conditions, e.g. outdoors.

Symptoms and effects of CTS can also occur and include:

- Tingling, numbness, pain, and weakness in the hand which can interfere with work and everyday tasks and might affect the ability to do work safely.
- Symptoms of both may come and go, but with continued exposure to vibration they may become prolonged or permanent and cause pain, distress, and sleep disturbance. This can happen after only a few months of exposure, but in most cases, it will happen over a few years.

Other things that can contribute to vibration risk include:

- **Low temperatures:** which increases the risk of finger blanching due to reduced blood circulation.
- **Smoking:** which can also result in reduced blood flow.

The use of the Stockholm scale to indicate severity

Part of the clinical assessment process for Hand arm vibration syndrome (HAVS) is medical examination. This involves the classification of vascular and sensorineural (nerve damage) symptoms. Previously, the Taylor-Pelmar classification was used. This has been replaced by The Stockholm scale, as shown in the tables that follow.

Vascular Component		
Stage	Grade	Description
0		No attacks
1_V	Mild	Occasional attacks affecting only the tips of one or more fingers
2_V	Moderate	Occasional attacks affecting distal and middle (rarely also proximal) phalanges of one or more fingers
3_V	Severe	Frequent attacks affecting all phalanges of most fingers
4_V	Very severe	As in stage 3, with trophic changes in the fingertips

Sensorineural Component	
Stage	Description
0	Vibration-exposed but no symptoms
1_{SN}	Intermittent numbness with or without tingling
2_{SN}	Intermittent or persistent numbness, reduced sensory perception
3_{SN}	Intermittent or persistent numbness, reduced tactile discrimination and/or manipulative dexterity

In the numerical scoring system for vascular HAVS, the blanching for each part of each digit is given a score as indicated on the diagram in the figure above. A total value for each hand can be arrived at by summing the digit scores. In the figure, the score for the left hand is 16 and that for the right hand is 4.

If an employee is diagnosed as having stage 2, the aim is to prevent stage 3 (vascular or sensorineural) developing because this is a more severe form of the disease associated with significant loss of function and disability.

Stage 2 sensorineural is broad, ranging from minor neurological symptoms to those with persistent sensorineural loss. Therefore stage 2 should be divided into 'early' and 'late' phases to assist with management of stage 2 cases.

Vibration risk assessment and planning for control

The aim of the risk assessment is to help you decide what you need to do to ensure the health and safety of your employees who are exposed to vibration.

The risk assessment should:

- Identify where there might be a risk from vibration and who is likely to be affected.
- Contain a reasonable estimate of employees' exposures
- Identify what needs to be done to comply with any legal/national requirements e.g. whether vibration control measures are needed, and, if so, where and what type
- Identify any employees who need to be provided with health surveillance and whether any are at particular risk.

The findings of the risk assessment should be recorded. An action plan should be developed to deal with anything that is found to be necessary to comply with the law.

The risk assessment should be reviewed if circumstances in the workplace change and affect exposures.

The risk assessment is likely to be suitable and sufficient if it identifies:

- Where there may be a risk from vibration.
- A soundly based estimate of your employees' exposures and a comparison.
- With the exposure action value and exposure limit value.
- The available risk controls.
- The identification of those individuals who may be more at risk.
- The steps you plan to take to control and monitor those risks.
- A record of the assessment.

To assess the daily exposure to vibration of a worker (or a group of workers doing similar work) it is necessary to know:

- Which tasks expose employees to vibration
- Which employees are exposed
- What equipment they use
- What they use it for
- The total time they are in contact with the equipment while it is operating.

These details can be obtained by observing the employee. The person need not be observed for a complete day, but for a period or periods long enough to provide a representative sample of a typical or average day's exposure to vibration. Observation of the work will generally produce a much more accurate indication of equipment usage time than asking the employee to make an estimate. Work patterns also need careful consideration. For example, some workers may only use vibrating tools for certain periods in a day or week. Typical usage patterns should be established as these will be an important factor in calculating a person's likely vibration exposure.

To be relevant, the vibration information you use to do your vibration assessment needs to match as closely as possible the likely vibration performance of the equipment to be used, and how it is used. There are several possible sources of suitable information on vibration levels. These include:

- Vibration emission values declared in the equipment handbook
- Additional information from the equipment supplier
- Internet databases
- Research organisations
- Vibration consultancies
- HSE's website
- Trade associations
- Measurements made in your own workplace

It is important to check that the vibration data is reasonably representative of your equipment as used in your work activities.

When carrying out an assessment, there is a need to be mindful of employees who are particularly sensitive to vibration, including employees who have existing vibration related diseases, or who suffer from circulatory issues (possibly related to smoking) or nerve disorders.

The employer is responsible for assessing the risks from vibration and developing an action plan. This does not have to be done by one individual. For example, you might decide to employ external assistance (specialist consultant) to help with your vibration risk assessment and to use members of your own staff (who understand your business) to plan and carry out the necessary actions to control the risks from exposure to vibration.

If you decide to employ external assistance to help you assess and manage vibration exposures, you will need to ensure that they have the necessary skills, knowledge, expertise, and experience. The UK HSE has produced a free pocket card (indg420) to help employers select a consultant to carry out many of the tasks required to properly assess and control vibration risks.

The use of vibration calculators to determine mixed exposures

Introduction

The UK HSE have produced calculators and a simple "exposure points" system. These are aimed at assisting/simplifying the calculation of HAV and WBV exposures of workers. Their operation is described as follows.

Ready reckoner points system

The table that follows is a 'ready-reckoner' for calculating daily vibration exposures using the vibration magnitude and exposure time. The ready-reckoner covers a range of vibration levels up to 40 m/s2 and a range of exposure times up to ten hours.

The exposures for different combinations of vibration magnitude and exposure time are given in exposure points instead of values in m/s2A(8). You may find the exposure points easier to work with than the A(8) values:

- Exposure points change simply with time: twice the exposure time, twice the number of points
- Exposure points can be added together, for example where a worker is exposed to two or more different sources of vibration in a day.
- The exposure action value (2.5 m/s2A(8)) is equal to 100 points.
- The exposure limit value (5 m/s2A(8)) is equal to 400 points.

Vibration magnitude. a_{hw} (m/s²)	5 min	15 min	30 min	1 h	1 h 30 min	2 h	3 h	4 h
40	265	800						
30	150	450	900					
25	105	315	625	1250				
20	67	200	400	800	1200			
19	60	180	360	720	1100	1450		
18	54	160	325	650	970	1300		
17	48	145	290	580	865	1150		
16	43	130	255	510	770	1000		
15	38	115	225	450	675	900	1350	
14	33	98	195	390	590	785	1200	
13	28	85	170	340	505	675	1000	1350
12	24	72	145	290	430	575	865	1150
11	20	61	120	240	365	485	725	970
10	17	50	100	200	300	400	600	800
9	14	41	81	160	245	325	485	650
8	11	32	64	130	190	255	385	510
7	8	25	49	98	145	195	295	390
6	6	18	36	72	110	145	215	290
5.5	5	15	31	61	91	120	180	240
5	4	13	25	50	75	100	150	200
4.5	3	10	21	41	61	81	120	160
4	3	8	16	32	48	64	96	130
3.5	2	6	13	25	37	49	74	98
3	2	5	9	18	27	36	54	72
2.5	1	3	6	13	19	25	38	50
2	1	2	4	8	12	16	24	32
1.5	0	1	2	5	7	9	14	18
1	0	1	1	2	3	4	6	8

Daily Exposure time

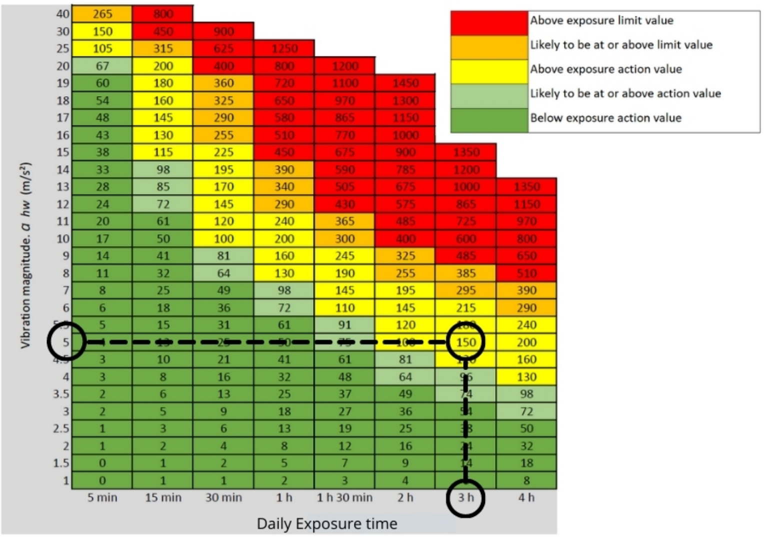
Using the ready-reckoner

1. Find the vibration magnitude (level) for the tool or process concerned (or the nearest value) on the grey scale on the left of the table.

2. Find the exposure time (or the nearest value) on the grey scale across the bottom of the table.

3. Find the value in the table that lines up with the magnitude and time. The completed example overleaf shows how it works for a magnitude of 5 m/s2 and an exposure time of 3 hours: in this case the exposure corresponds to 150 points.

4. Compare the points value with the exposure action and limit values (100 and 400 points respectively). In this example the score of 150 points lies above the exposure action value. The colour of the square containing the exposure points value tells you whether the exposure exceeds, or is likely to exceed, the exposure action or limit value.



If a worker is exposed to more than one tool or process during the day, repeat steps 1-3 for each one, add the points, and compare the total with the exposure action value (100) and the exposure limit value (400).

Hand arm vibration calculator

The UK HSE's on-line exposure calculator for hand-arm vibration is an alternative to the ready-reckoner for calculating daily exposures quickly and easily. The calculator is available in the vibration section of the HSE website at www.hse.gov.uk/vibration. (Note that there are different calculators for hand-arm vibration and whole-body vibration.).

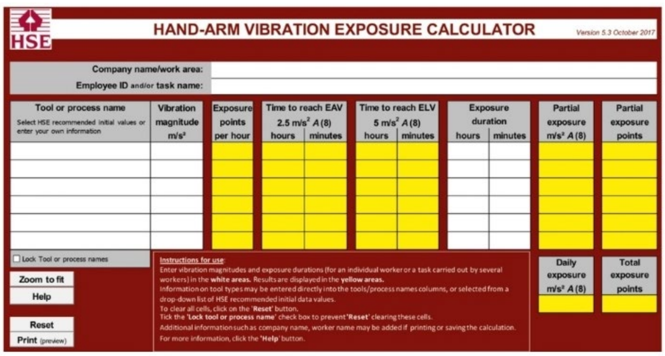


Image source https://www.hse.gov.uk/vibration/hav/vibrationcalc.htm

1. The calculator may be used online or, if you prefer, it can be downloaded and saved on your computer as a spreadsheet file (Microsoft Excel).

2. Click on the white areas and type in a vibration magnitude (in m/s2) and an exposure duration (in hours and/or minutes). You can do this for up to six different tools or processes.

3. When you have entered all the numbers, press the ENTER key, or click on a different cell. The following values will then be calculated and displayed in the yellow cells on the right.

The **Partial exposure** is the vibration exposure (shown in both m/s2A(8) and exposure points) for each individual tool or process and is calculated from the Vibration magnitude and the Exposure duration.

The **Daily exposure**, also in m/s2A(8) and exposure points, is calculated from the Partial exposures.

4. In addition to the partial and total exposure values, the calculator also uses the vibration magnitudes to produce the following values:

Exposure points per hour. The number of exposure points for every hour of exposure time for the individual tool or process.

Time to reach EAV (exposure action value). This is the total exposure time required for the individual tool or process before the exposure action value (2.5 m/s2A(8) or 100 points) is reached.

Time to reach ELV (exposure limit value). This is the total exposure time required for the individual tool or process before the exposure limit value (5 m/s2A(8) or 400 points) is reached.

5. The figures that follow show the calculator in use. In this example, an operator uses three tools during a working day. The vibration magnitudes are 2, 6 and 3.5 m/s2 and the total exposure times are 15, 30 and 90 minutes, respectively. These values have been typed into the white cells (you can use hours, minutes, or a combination of the two for the exposure duration). The results (in the yellow cells) show the partial exposure values for the three tools and the total exposure which, at 2.2 m/s2 A(8) or 75 points, is below the exposure action value.

6. The cells can be cleared for another calculation by clicking on the Reset button in the bottom right-hand corner.

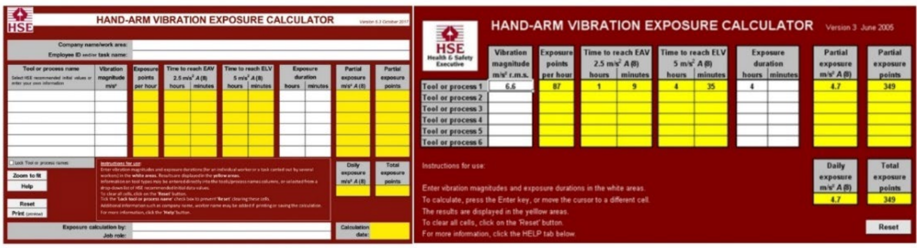


Image source - https://www.hse.gov.uk/vibration/hav/vibrationcalc.htm

Whole body vibration calculator

The calculator below can be used to calculate WBV exposure levels. The calculator may be used online or, if you prefer, it can be downloaded and saved on your computer as a spreadsheet file (Microsoft Excel).

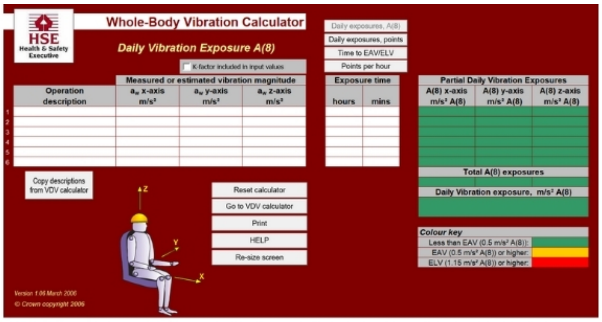


Image source - https://www.hse.gov.uk/vibration/wbv/calculator.htm

Simply insert the measured or estimated vibration values in the white boxes, together with the exposure hours. The calculator will then work out daily exposures; time to EAV/ELV and daily exposure points, as indicated in the example below which shows that the ELV of 1.29 m/s2 exceeds the exposure limit value of 1.15 m/s2.

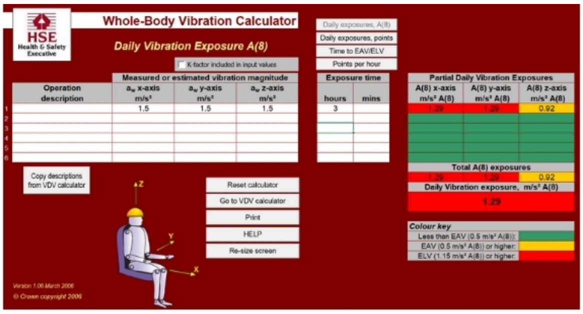


Image source - https://www.hse.gov.uk/vibration/wbv/calculator.htm

Practical control measures to prevent or minimise exposure

Your assessment of vibration should first consider the actions that could be taken to reduce vibration exposure. The hierarchy for control which minimises the risk from vibration exposure, in order of priority, is as follows:

(a) Eliminate vibration exposure by changing the work processes
(b) Reduce exposure by mechanisation
(c) Reduce exposure by good process control
(d) Avoid high-vibration tools, machines, and accessories
(e) Maintain machines and accessories
(f) Reduce the transmission of vibration into the hand
(g) Reduce the durations of exposure (including job rotation)
(h) Keep warm and dry

Eliminate vibration exposure by changing the work processes

The most effective and reliable way of eliminating the risk from vibration is to design (or redesign) work processes so that employees are not exposed to vibration at all. Where large reductions in vibration exposures are required, this

approach is sometimes the only way of adequately controlling the vibration risk, and it will often prove cost-effective in the long term.

Re-engineering industrial processes often requires review of formal standards (such as production methods or finishes agreed with customers) before the required changes can be put in place.

Reduce exposure by mechanisation

Mechanisation, the use of robotics, remote control or other forms of automation can eliminate or reduce exposure. For example: In the foundry industry, using manipulators and remote-control swing grinders allows more force to be applied during fettling than is possible with a hand-held grinder and productivity can be increased.

Reduce exposure by good process control

Good process control is important for maintaining product quality, production efficiency and controlling vibration exposure. For example, improving the quality control of car-body panel pressing to keep the press-shop dies clean and in good order reduces the need for reworking with powered hand-held tools to remove blemishes in the product.

Avoid high-vibration machines and accessories

After doing all that is reasonably practicable to replace or modify work processes, employees may still be exposed to vibration. If so, unnecessarily high vibration exposures should be avoided by careful selection of power tools and other equipment.

This can be done by:

(a) reviewing the available vibration emission information for machines of a similar type and determining the range of vibration emission values that are declared for competing machines

(b) deciding a maximum level of vibration emission for a machine class for future purchase or hire.

(c) asking suppliers to provide tools or consumables (such as grinding wheels) for trial by the prospective users.

Maintain machines and accessories

Power tools and other work equipment should be serviced and maintained in accordance with the manufacturer's maintenance schedules. In some cases, maintenance is essential to prevent unnecessarily high vibration levels and ensure efficient operation. This maintenance may include:

(a) keeping cutting tools sharp
(b) dressing grinding wheels correctly
(c) replacing worn parts
(d) carrying out necessary balance checks, tensioning, and other corrections
(e) checking and replacing defective vibration dampers, bearings, and gears
(f) tuning and adjusting engines

Reduce the transmission of vibration into the hand

When the use of vibrating equipment and exposure to vibration is unavoidable, it is often possible to control the extent to which damaging vibration is transmitted to the hand by minimising grip and push (sometimes known as feed) forces.

Gripping or pushing forces are necessary to support the machine or workpiece, to control or guide the machine, or to achieve high working rates. However, it is often found that the forces used are greater than those needed for efficient and safe use of the machine. The cause of these excessive forces may be incorrect equipment selection, inadequate maintenance, insufficient operator training or poor workstation design. It is important to remember that the greater the gripping or pushing forces exerted through the hand onto the vibrating surface, the more efficiently the vibration passes into the user's hand and arm. Improvements that may reduce unacceptably high gripping and pushing forces include:

a) providing additional support where heavy workpieces are ground by hand at pedestal grinders (providing a support for the whole piece will mean that the worker needs only to guide it and hold it against the wheel, rather than support all the weight).
b) changing the texture and material of a grip surface so that the operator may be able to use a lighter grip force to hold and control the machine.

Reduce the durations of exposure (including job rotation)

When the vibration levels have been reduced so far as is reasonably practicable, further reduction in exposure can only be achieved by limiting the time for which employees are exposed to vibration. Limiting the duration is sometimes essential to keep exposures below the ELV.

Job rotation (sharing the work and the vibration exposure between several people) can be used to reduce exposure of some individuals, at the expense of increasing the exposure of other individuals. Job rotation is an inefficient way of reducing exposure. For example, if one job, completed by one person, results in one exposure at the ELV, using job rotation to achieve all exposures below the EAV would require job rotation for at least four people.

Keeping warm and dry

Low hand or body temperature increases the risk of finger blanching because of reduced blood circulation. Gloves and other warm clothing can help vibration-exposed workers maintain good circulation.

Information and training for operators and supervisors. The co-operation of the workforce is required to make control measures effective in controlling the risk from any remaining vibration exposure. It is important that operators and their supervisors receive information about the risks from vibration and that they receive the required instruction and training in the correct use and maintenance of the equipment they use.

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The advantages and disadvantages of wearable technologies

The advantages of wearable technologies are that they can track the health of an individual whether that be through vibration monitoring or exposure to radiation by wearing of a personal dosemeter and if needs be alert the user if their exposure levels are too high. This in turn may increase productivity.

The disadvantages are that some workers may see the wearing of technologies as an invasion of privacy and feel that an employer is tracking their everyday movements within the workplace.

There is also the issue about battery life and how effective wearable technologies are if they are not charged on a regular basis.

Wearable technologies connect to wireless networks, generate artificial Electromagnetic Fields, and can cause long term effects to a person's health. This can include side effects such as feeling dizzy and suffering from headaches, heart palpitations and skin rashes.

9.13: Radiation

The distinction between ionising and non-ionising radiation

Radiation involves a transfer of **energy** through space.

Depending on the amount of energy carried by radiation, radiation can be classified into ionising radiation and non-ionising radiation.

The main difference between ionising and non-ionising radiation is that ionising radiation refers to types of radiation where the radiation carries enough energy to ionise atoms (such as human body cells), whereas non-ionising radiation refers to types of radiation that do not carry enough energy to ionise atoms (although it can heat/burn human organs).

The electromagnetic spectrum

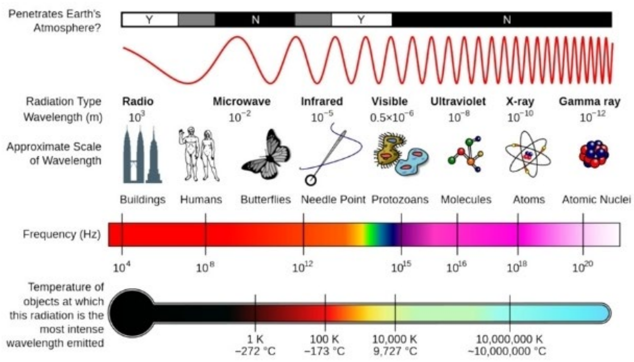
Radiation is physical energy that moves in a wave like motion.

X-rays, the light we can see from the sun or a light bulb, microwaves, and radio waves are all forms of radiation.

The Electromagnetic Spectrum shows the wave like motion of radiation. The distance from the top of one wave to the top of the next wave is the wavelength.

The **frequency** is the number of waves that pass each second, or cycles. Frequency, or the number of cycles, is measured in units called Hertz (Hz). One Hz is equal to one cycle per second. The shorter the wavelength, the greater the radiation energy.

Common types of radiation are shown in the figure that follows.



The differences can be compared to the display on a radio. The frequencies of different types of radiation are shown from highest to lowest.

As shown in the figure that follows, radiation is divided into two kinds, ionising and non-ionising.

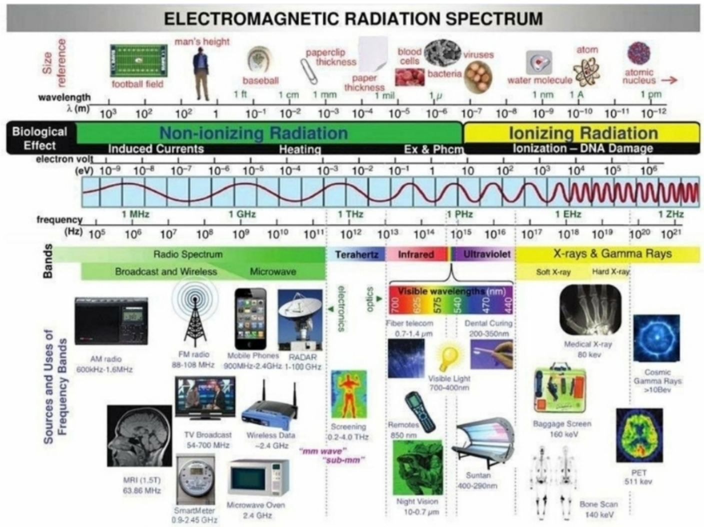


Image source - https://www.pinterest.co.uk/pin/795026140446809054/

Particulate Radiation (alpha, beta, and neutrons)

A form of ionising radiation, particle radiation refers to a stream of atomic or subatomic particles that may be charged positively (e.g. alpha particles) or negatively (e.g. beta particles) or not at all (e.g. neutrons).

Alpha particles and beta particles are considered directly ionizing because they carry a charge and can, therefore, interact directly with atomic electrons through coulombic forces (i.e. like charges repel each other; opposite charges attract each other).

The neutron is an indirectly ionizing particle. It is indirectly ionizing because it does not carry an electrical charge. Ionization is caused by charged particles, which are produced during collisions with atomic nuclei.

Alpha Particles

Alpha particles are released by high mass, proton rich unstable nuclei. The alpha particle is a helium nucleus; it consists of two protons and two neutrons. It contains no electrons to balance the two positively charged protons. Alpha particles are therefore positively charged particles moving at high speeds.

Alpha particles are relatively large and only travel short distances (a few centimetres.) They are unlikely to penetrate living tissue, and the epidermis of the skin will prevent entry. Alpha particles are therefore the least penetrating and can be stopped by a sheet of paper.

The main risk from alpha particles is through ingestion or inhalation, placing it close to vulnerable tissue. As a result, the high localised energy effect can destroy the tissue of the affected organs. Alpha particles are naturally emitted by all the larger radioactive nuclei such as uranium, thorium, actinium, and radium.

Examples of sources and uses of alpha radiation include smoke detectors; as an industrial tracer (to find blockages in vessels, equipment.) or in anti-static devices.

Beta Particles

Beta particles are emitted by neutron rich unstable nuclei. Beta particles are high energy electrons. These electrons are not electrons from the electron shells around the nucleus but are generated when a neutron in the nucleus splits to form a proton and an accompanying electron. Beta particles are negatively charged.

Beta particles are smaller in mass than alpha particles but have a longer range (a few metres). They can cause skin burns or damage to the eyes. Whilst it can penetrate the skin internal organs are unlikely to be damaged - since the penetration stops in a couple of centimetres - unless deposited by ingestion. Whilst more penetrating than alpha particles, beta particles are less ionising and therefore take longer to inflict the same degree of damage. Beta particles can be stopped by a thin piece of aluminium.

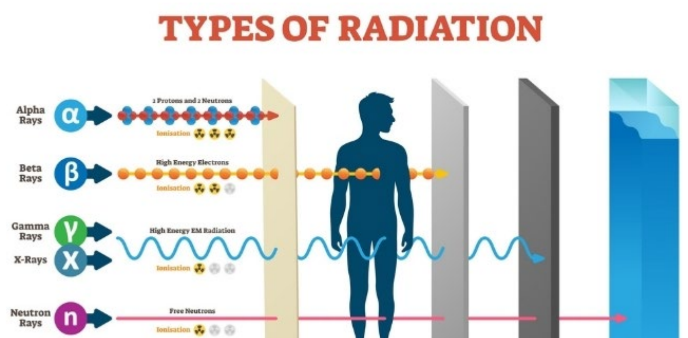
Examples of naturally occurring beta emitters include Tritium, Carbon 14 and Phosphorous 32 (all used as radiotracers in research.) Industrial uses of beta radiation include thickness measuring gauges (such as the thickness of paper coming through a roller.)

Neutrons

Neutron radiation is a kind of ionising radiation which consists of free neutrons. A result of nuclear fission or nuclear fusion, it consists of the release of free neutrons from atoms, and these free neutrons react with nuclei of other atoms to form new isotopes, which, in turn, may produce radiation.

Neutrons are high-speed nuclear particles that have an exceptional ability to penetrate other materials. Of the types of ionising radiation discussed here, neutrons are the only one that can make objects radioactive (including the human body.) This process, called neutron activation, produces many of the radioactive sources that are used in medical, academic, and industrial applications (including oil exploration).

Because of their exceptional ability to penetrate other materials, neutrons can travel great distances in air and require very thick hydrogen-containing materials (such as concrete or water) to block them. Boron is also an excellent neutron absorber. Fortunately, however, neutron radiation primarily occurs inside a nuclear reactor, where many feet of water provide effective shielding.



Non-Ionising Radiation

Sources of Non-Ionising Radiation

Non-ionising radiation can be found in many different types of workplace, both naturally occurring and emitted from artificial sources.

The leisure industry makes use of bright lights (optical radiation), lasers, and ultra-violet lights for entertainment purposes. Large events will even make use of radios for communication. Generally, sources of radio and UV radiation are typically not a concern due to their low power. However, high power lasers can present various health risks when shone directly at audiences, especially if they shine into people's eyes. Tanning salons operate sunbeds, which create large amounts of UV radiation.

The manufacturing industry often makes use of heat. Heat is a form of infrared radiation. Steelworks, and other metallurgical industries, and associated furnaces generate large amounts of heat which can damage both the skin and eyes. Large amounts of optical radiation may also be used, when lighting levels need to be especially bright for detailed work. Some manufacturing processes may involve welding, which generates UV radiation which can damage the eyesight of the welder and anyone watching the welding process.

UV radiation is widely used in industrial processes and in medical and dental practices for a variety of purposes, such as killing bacteria, creating fluorescent effects, curing inks and resins. UV radiation is also used to treat several diseases, including rickets, psoriasis, eczema, and jaundice. Low power lasers are used to treat skin conditions. High power lasers are used to cut skin during surgical operations, as well as to coagulate and vaporise.

The research industry uses many sources of non-ionising radiation. IR sources include thermography, remote control devices and IR spectroscopy analysis of molecules. Lasers are used to vaporise materials, in chemical analysis, for distance measurement, and in research for nuclear fusion technology.

The telecommunications industry uses large amounts of radio and microwave radiation. Transmitter towers emit high-frequency radio and microwaves. Whilst these pose no risk to the neighbours, they can be hazardous for maintenance engineers who must work in close proximity to them.

Non-ionising radiation is naturally occurring. We are bombarded by natural cosmic radiation all the time. UV radiation can be a significant hazard if working outdoors in the sunlight. Some industries, such as construction and agriculture, are predominantly outdoor industries. In certain countries, or in the summer, workers may be exposed to large amounts of UV radiation. In the short-term, this may only cause sunburn, followed by a sickness absence in severe cases. In the long-term, it leads to a statistically higher risk of skin cancer.

It is also worth noting that a lack of UV exposure is also potentially unhealthy. UV exposure enables our bodies to produce vitamin D, without which we develop many ill-health problems with regards our bones, teeth, and muscles. A chronic lack of vitamin D can also lead to a higher cancer risk. Workers who stay permanently indoors, or work nights, especially in colder climates, may suffer from vitamin deficiency.

The Routes and Effects of Exposure

All non-ionising radiation has similar effects on the body, especially at higher powers. It affects the skin and the eyes.

Effects on the Skin

The acute effects are mainly local heating of the skin tissues, leading to reddening of the skin (also called erythema), and eventually burns. For example, exposure to a class 3 laser or excessive levels of IR or UV (such as sunlight) will lead to local burning of the skin. Maintenance engineers working near microwave dishes have been burnt from the microwave radiation.

Chronic exposure leads to degenerative changes in cells of the skin, premature skin ageing, and an increased risk of skin cancer. Regular and repeated damage to the skin leads to chronic damage of the DNA. Eventually, this can cause skin cancer, including the most dangerous type: malignant melanoma. UV radiation from the sun is renowned for increasing skin cancer levels. The construction industry in the UK has a 30% higher rate of skin cancer compared to most other industries. And there is not a lot of sunshine in the UK!

There are different types of UV radiation. UV-C is the most dangerous, but this is absorbed by the ozone layer of our atmosphere before it reaches the Earth. Therefore, UV-C from the sun does not affect people. However, some artificial sources of UV-C do exist, and these must be closely managed. The naturally occurring UV-B is the primary concern in relation to sunlight.

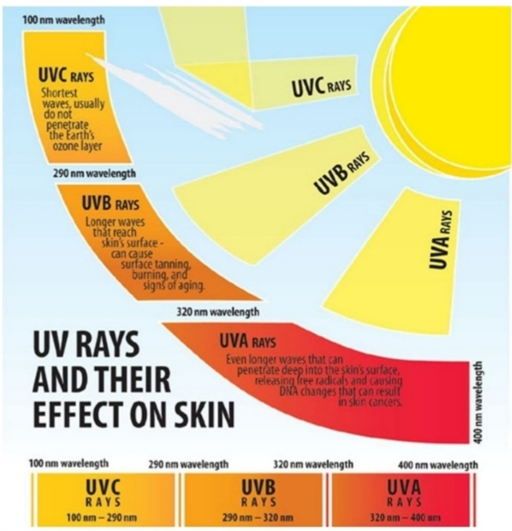


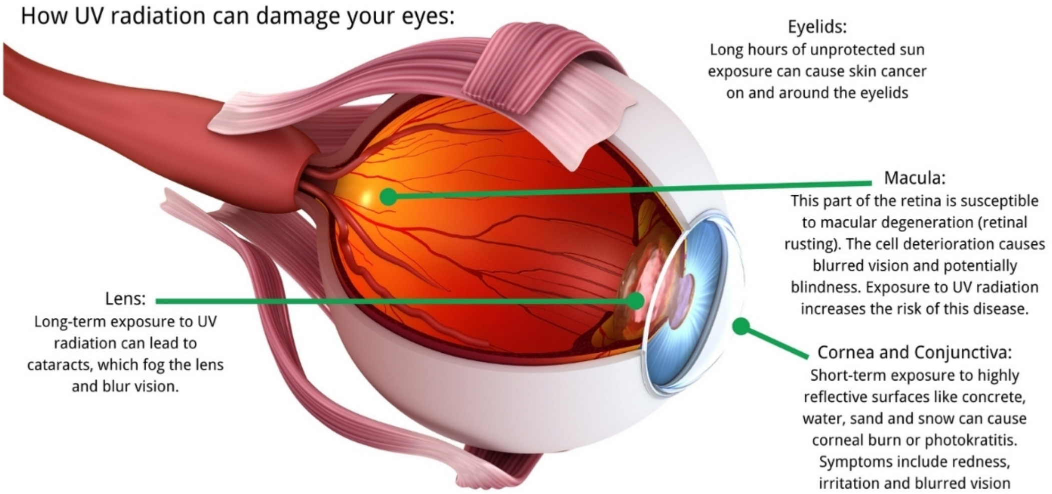
Image source - https://www.pinterest.at/pin/299630181440573704/

Effects on the Eyes

The eyes are particularly sensitive to non-ionising radiation.

High bursts of IR and UV, even for just a few seconds, can result in a painful, but a temporary condition known as photokeratitis and conjunctivitis.

Photokeratitis is a painful condition caused by the inflammation of the cornea of the eye. The eye waters and vision are blurred. Conjunctivitis is the inflammation of the conjunctiva (the membrane that covers the inside of the eyelids and the sclera, the white part of the eyeball). This becomes swollen and produces a watery discharge. It causes discomfort rather than pain and does not usually affect vision.



Photokeratitis ("welders’ flash" or "arc-eye") is an acute condition that occurs because of exposure to UV-B or UV-C. The symptoms are pain, discomfort like having sand in the eye, and an aversion to bright light. This condition affects the thin surface layer of the cornea (the clear front window of the eye) and the conjunctiva. Symptoms normally dissipate within 48 hours. It is like the condition "snow blindness", which occurs in cold climates after lengthy exposure to the bright reflection of sunlight off the snow.

The chronic effects of UV and IR radiation on the eyes are the formation of cataracts. These are when the cornea become less transparent, impeding vision, and eventually causing blindness. They occur naturally with age, but long-term exposure to radiation can cause these to occur much earlier than normal. Surgery on the eye, often using lasers, is required to remove them.

Lasers can also affect the eyes. Even a short flash from a low power laser can cause a temporary residual after image or flash blindness, such as after being exposed to a bright light. High power lasers can cause instantaneous damage to the retina. When the laser enters the eye, the cornea (which is basically a lens) focuses the laser beam even more tightly, causing it to burn the retina. This can cause a permanent blind spot in the eye.

With the increasing use of LED lights, we are becoming more aware of the hazards of "blue light". LED lamps are becoming more powerful, and they emit a higher proportion of blue light compared to other visible lights. The blue

part of the visible light spectrum contains the greatest amount of power. The light is not absorbed by the cornea of the eye. Instead, it impacts directly onto the retina. Lengthy exposures, such as looking directly and closely at a bright LED lamp for longer than 10 seconds can lead to temporary damage. The longer the exposure, the more likely the damage will become permanent and cause blind spots on the retina.

Non-Ionising Radiation Risk Assessment

Risk assessment of non-ionising radiation hazards is a general requirement of Directive 89/391/EEC and detailed in section 7 of the ILO Code of Practice "Ambient factors in the workplace".

Amongst other things, the risk assessment should consider:

- The sources of non-ionising radiation.
- Comparison between measurements of exposure and any applicable exposure limits.
- The potential for misuse or misunderstanding of safety precautions.

Control Measures to Minimise Exposure to Non-Ionising Radiation

Design

The hierarchy of control measures is based on the principle that if any hazard is identified and cannot be eliminated or reduced, then this hazard must be controlled by engineering design. Only when this is not possible, should alternative protection be introduced. There are very few circumstances where it is necessary to rely on personal protective equipment and administrative procedures.

The equipment should be designed so that it uses the lowest amount of power possible whilst still performing its function. For example, lasers should be of the lowest class possible. Microwave and RF transmitters should use the least power possible. Ceiling lights that use fluorescent tubes should be designed with diffusers to diffuse the light over a wide area.

Many laser products are designed so that they require a key to operate. This enables the organisation to use a key control system of work, only allowing competent personnel to obtain the key and switch the laser on.

Siting and Direction Control

The equipment should be positioned in a safe place, preferably as far away from workers as is reasonable given the risk and the task. The equipment should direct the radiation in a safe direction. For example, the barcode scanners at

supermarket checkouts are positioned and directed in such a way that it is difficult for the checkout operators to look directly into the laser beam.

Another example is sunbeds in tanning salons. There is always a small amount of UV radiation which escapes from the sunbed, usually from the doors. These should be directed away from any workers in the salon i.e. direct the UV radiation away from the working area and reception desk.

In the entertainment industry, lasers must be positioned at a safe height, so they fire their beams over the heads of the crowd. The lighting engineer must avoid pointing lasers towards the bar area.

Reduction of Stray Fields and Beams

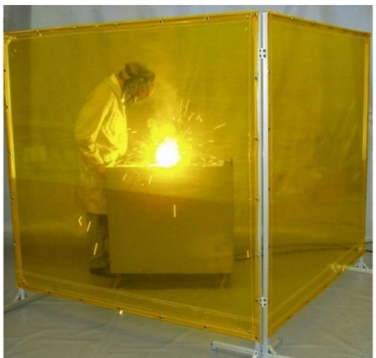
Wherever possible the equipment should be designed and maintained so that non-ionising radiation does not escape. Gaps in the body should be sealed, and ventilation points positioned in such a way to minimise the likelihood of light or fields escaping.

Where using optical sources of radiation, these may get reflected off shiny surfaces. Ideally, these surfaces should be eliminated so they absorb rather than reflect. However, an alternative is to design the surfaces so that any reflected light is diffused and scattered over a wide area. This is particularly useful with lasers. Certain lasers are harmful when shone directly into the eyes, but diffusely reflected beams are safe.

Screening and Enclosures

Screening

Screens and barriers can be erected between the worker(s) and the source of radiation. For example, a welder could erect a portable welding screen around the welding area to prevent UV radiation from being seen by workers nearby. A fixed barrier could be erected to shade workers from the sun during their rest break, or from the radiant heat of a furnace.



Enclosures

The source of radiation can be fully or partially enclosed. It is then possible to monitor the process remotely, via a suitable viewing window, optics, or television camera. Safety can be ensured by using appropriate filter materials to block the transmission of hazardous levels of radiation. This removes any need for reliance upon safety goggles and improves operator safety and working conditions. For example, the laser source on a barcode reader is almost entirely enclosed, and its direction strictly controlled. The enclosure prevents stray laser beams from being emitted in any other direction.

Access to microwave and RF transmitters is restricted, requiring engineers to enter through locked doors. Locking sources away and controlling access to keys can be a simple yet effective method of enclosing the hazard.

Transmission of optical radiation through windows and other optically translucent panels should be evaluated as a potential risk. Although the optical beam may not present a direct retinal hazard, temporary flash issues may cause secondary safety problems with other procedures in the vicinity. If the enclosure is guarding against UV radiation, the windows can filter UV radiation and protect operators outside.

It may be necessary to remove guards or parts of the enclosure during maintenance, repairs, or even during normal use. The occasional removal is normally controlled through a Lock-Out Tag Out system, and possibly even a Permit to Work system. But for regular removal of guards during normal use, it is necessary to install an interlock or a trip system. The principle is that, if an operator opens the guard or enters a danger area, the interlock or trip system is activated and turns off the power to the machine before harm can occur.

There are many variations of interlock switches and each design comes with its own features. It is important that the right device is chosen for the application. Interlocks should be "fail to safe" and be "tamper proof."

Safe by Distance

The further away people are from the non-ionising radiation source, the lower their level of exposure. Every time the distance is doubled, the exposure decreases by a factor of four.

A simple barrier or temporary cordon can be positioned around the working area to keep people at a safe distance.

Safe Systems of Work

Safe systems of work need people to act on information and, therefore, are only as effective as the actions of those people. However, they do have a role and may be the principal control measure under some circumstances, such as during commissioning, maintenance, and repair work.

Systems may include the need for effective isolation of equipment before removing guards, using a Lock-Out Tag Out system, or simply by removing the plug from the electrical socket.

If isolation is not possible (for example, if the equipment must remain in operation for the engineer to diagnose a fault), then safe systems of work should be documented and used to identify the safe working methods to be used. These may include carrying out the work in an enclosed and separate area and using PPE to protect the skin and eyes.

Instructions and Training

Where all the sources are considered 'trivial' then it should be adequate to inform workers of this. However, workers should be made aware that there could be people who are vulnerable to certain types of non-ionising radiation, and the process for managing these.

When workers are trained in the use of equipment, they should receive information on the hazards, the risks to themselves (acute and chronic health effects to the skin and eyes), and what precautions they should take (for example, not looking directly at sources of bright blue light, not pointing lasers towards people, and not tampering with the body of any equipment, cover exposed skin when working in the sun, etc).

Where there is exposure that is likely to exceed the exposure limit value is present in the workplace then consideration should be given to formal training on non-ionising risks and ensuring supervisors and managers are also trained so they understand the need for them to supervise effectively. Engineers or those who maintain the equipment should receive additional training on how exposure could occur when dismantling the equipment, and the safe methods to be followed.

Users of equipment must be instructed in how to carry out a pre-use examination of their equipment and what faults they might identify. The organisation must have an effective reporting procedure, and the user must be instructed in who to inform about the fault and what action to take with the equipment (e.g. quarantine procedure, how to obtain a replacement, etc).

Personal Protective Equipment

PPE is the last resort of the hierarchy of controls. Since the risks are to the skin and eyes, the PPE will be overalls, gloves, and/or eye protection.

The type of eye protection will vary depending on the type of radiation it is designed to protect against. It could range from solar protection sunglasses for outdoor work, to certified laser safety glasses filtering out infrared radiation, to a full welder's face shield. In addition, there may be other hazards such as flying objects or liquid splashes, and the eye protection may also have to protect against these.

Skin protection is usually made of overalls and/or gloves. These protect the skin from all but the most extreme non-ionising radiation, such as infrared (heat), UV rays from processes and sunlight, and skin burns from lasers. For the stronger types of non-ionising radiation, overalls can be flame-resistant or fire-retardant.


For protection against solar UV radiation, employers can provide long, loose clothing, preferably white, and with an in-built UV protecting rating. On construction sites, neck protection can be attached to hard hats to prevent sunburn on the neck.

Not quite PPE, but strongly linked to it, are sun creams. These can provide significant protection if used correctly. Where working in strong sunlight cannot be avoided, and skin cannot be fully covered, employers may want to encourage workers to wear sun cream (or even provide it) to reduce levels of absence due to sunburn and cancers.




Ionising radiation

Sources of ionising radiation

Ionising radiation sources are used in medicine (for diagnosis and treatment), industry (for measurement and other purposes as well as for producing energy) and in research and teaching.

Maybe the most known use of ionising radiation is in diagnostic medicine. If someone has an internal injury, it is almost certain that he/she will be sent for an X-ray examination. X-rays are produced in X-ray tubes. They enter the patient's body on one side and leave on the opposite side, where a detector is installed. Since X-rays are attenuated differently in different tissues, we get an X-ray image of the patient's internal organs and bones. From the image, a doctor can see where the anomaly is in the patient's body.

Ionising radiation is also used for treatment in oncology. Cancerous growths can be killed if large doses of ionising radiation are delivered to it. Of course, every treatment with ionising radiation sources must be well planned since radiation can also kill healthy cells.

The use of ionising sources in industry is widespread. Ionising radiation sources are used on vessels for level detection for example. It can be found in breweries where on the assembly line production an ionising radiation source is installed on one side of the line and a detector on the other. Radiation travels from the source to the detector. If a bottle passing between is full, the radiation is absorbed into the beer and only a small fraction of emitted radiation reaches the detector. This produces a "pass" indication, and the bottle can proceed to another phase of production. It the bottle is not full, more radiation reaches the detector, giving a "fail" indication and the bottle is ejected from the production line.

Ionising radiation is often used for non-destructive testing. The method is like diagnostic use in medicine. Ionising radiation penetrates pipes, tubes, casts, or other products where on the other side is a detector, usually to ionising radiation sensitive film. The image on the film shows if there are any defects in the object such as cracks, homogeneities, or foreign material.

In some industries, accumulation of naturally occurring radioactivity can occur. Everything around us is radioactive. In some cases, this natural radioactivity can accumulate. It accumulates in the Oil and Gas industries. We drill into solids to extract oil. Solids may contain naturally occurring radioactive material that can accumulate in vessels or deposit on internal surfaces. Workers working near such places are exposed to elevated levels of ionising radiation. In the zircon sand industry, workers might be exposed to naturally occurring radiation since elevated levels of uranium and thorium can be found in zircon.

Probably everyone has experienced an x-ray check of baggage at the airport. Passenger baggage is put on a conveyer and sent through an x-ray device. The security officer can see on the monitor if some suspicious objects are in the baggage. The method is very similar to that used in medicine.

In the nuclear industry, ionising radiation is not used but is a product of the nuclear reaction. For electricity production, we use heat generated during the reaction. The radioactive atoms that also originate from a nuclear reaction emit ionising radiation. Since these radioactive atoms and ionising radiation is the by product and cannot be used in the process, it becomes radioactive waste.

Naturally Occurring Radioactive Material (NORM)

Some processes with a recognised potential to cause significant radiation exposure to occur in the oil and gas industry where naturally occurring radium and its daughters, may build up over time as scale in pipes and vessels.

Some metal smelting applications may also cause exposure to NORM; here naturally occurring radionuclides may concentrate in foundry slag or may be present in radio-logically significant concentrations in refractory sands which contain low concentrations of natural uranium and thorium.

Exposure arising from work with materials that contain NORM, can sometimes come directly from the raw materials themselves, but more commonly results from their processing.

It is estimated that natural sources of ionising radiation account for some 86% of our average annual radiation dose.

Radon

Radon is a naturally occurring radioactive gas that can seep out of the ground and build up in houses and indoor workplaces. The highest levels are usually found in underground spaces such as basements, caves, and mines. High concentrations are also found in ground floor buildings because they are usually at slightly lower pressure than the surrounding atmosphere; this allows radon from the sub-soil underneath buildings to enter through cracks and gaps in the floor.

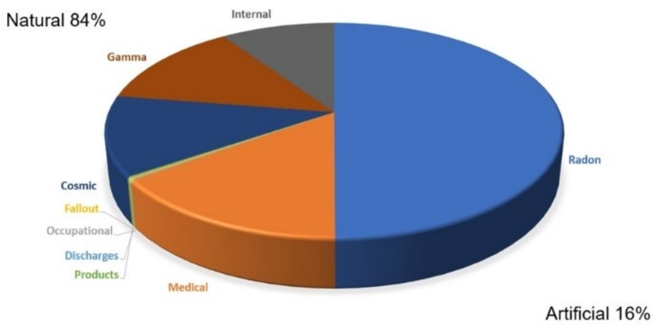
Radon (more properly known as radon-222) comes from uranium which occurs naturally in many rocks and soils. Most radon gas breathed in is immediately exhaled and presents little radiological hazard. However, the decay products of radon (radon daughters) behave more like solid materials than a gas and are themselves radioactive. These solid decay products attach to atmospheric dust and water droplets which can then be breathed in and become lodged in the lungs and airways.

Some decay products emit particularly hazardous radiation called alpha particles which cause significant damage to the sensitive cells in the lung.

Radon is now recognised to be the second largest cause of lung cancer in the UK after smoking. Lung cancer is also the biggest cause of cancer related death in the UK and only 5% of all lung cancers are curable.

Radon contributes by far the largest component of background radiation dose received by the UK population and, while the largest radon doses arise in domestic dwellings (due to the longer time spent there), significant exposures are possible in workplaces.

Chart showing the sources of the UK radiation exposures



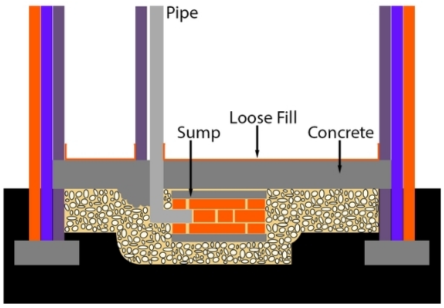
Underground workplaces such as basements mines, caves and utility industry service ducts can have significant levels of radon as can any above-ground workplaces in radon Affected Areas. All workplaces including factories, offices, shops, classrooms, nursing homes, residential care homes and health centres can be affected. Whilst employers who only occupy parts of buildings from the first floor and above are unlikely to have significant radon levels, employers who use cellars, basements and poorly ventilated ground floor rooms are far more likely to have problems with radon levels.

Practical control of radon in buildings

Radon enters a building primarily by airflow from the underlying ground and protection measures for reducing levels inside workplaces vary depending upon the severity of the problem and the type of building construction. New buildings can be protected during construction by installing a 'radon proof barrier/membrane' within the floor structure and, in more seriously affected areas, provision of a ventilated sub-floor void or a 'radon sump'.

A radon sump is a small, bucket sized, cavity under the floor with an electric pump drawing air from it. This reduces the normal under floor pressure with respect to radon in the soil and vents the radon gas outside the building where it quickly dissipates.

In existing buildings, it is not possible to provide a radon proof barrier and so alternative reduction measures are used depending upon the severity of the problem. Such measures include improved under floor and indoor ventilation in the area, sealing large gaps in floors and walls in contact with the ground, positive pressure ventilation of occupied areas, and installation of radon sumps and extraction pipework.



Radon sump

The Routes & Effects of Exposure to Each Type of Ionising Radiation

Introduction

Extreme doses of radiation to the whole body (around 10 sievert and above), received in a short period, cause so much damage to internal organs and tissues of the body that vital systems cease to function, and death may result within days or weeks.

Very high doses (between about 1 sievert and 10 sievert), received in a short period, kill large numbers of cells, which can impair the function of vital organs and systems.

Acute health effects, such as nausea, vomiting, skin, and deep tissue burns, and impairment of the body's ability to fight infection may result within hours, days, or weeks.

The extent of the damage increases with dose. These effects are called 'deterministic' effects and will not be observed at doses below certain thresholds. By limiting doses to levels below the thresholds, deterministic effects can be prevented entirely.

Exposure to Alpha Particles

The health effects of alpha particles depend heavily upon how exposure takes place. External exposure (external to the body) is of far less concern than internal exposure because alpha particles lack the energy to penetrate the outer dead layer of skin. However, if alpha emitters have been inhaled, ingested (swallowed), or absorbed into the blood stream, sensitive living tissue can be exposed to alpha radiation.

The resulting biological damage increases the risk of cancer, alpha radiation is known to cause lung cancer in humans when alpha emitters are inhaled. The greatest exposure to alpha radiation for average citizens comes from the inhalation of radon and its decay products, several of which also emit potent alpha radiation.

Perhaps the best-known example of the damage that can be caused by alpha particles was the worldwide media coverage of the poisoning of the former Russian officer, Alexander Litvinenko in 2006. Mr Litvinenko suddenly fell ill and was hospitalised. He died three weeks later as a result of polonium poisoning.

Exposure to Beta Particles

Acute exposure is said to be uncommon.
Chronic exposure occurs when low-level exposures occur over a long period of time (e.g. 5 to 30 years).
Iodine-131 concentrates in the thyroid gland, increasing the risk of thyroid cancer.
Strontium-90 accumulates in bone and teeth, causing damage to teeth and increasing the risk of bone cancer.

Exposure to Gamma or X rays

Because of the gamma rays' penetrating power and ability to travel great distances, it is considered the primary hazard to the general population during most radiological emergencies.

Both direct (external) and internal exposure to gamma rays or X-rays are of concern.

Gamma rays can travel much farther than alpha or beta particles and have enough energy to pass entirely through the body, potentially exposing all organs.

X-ray exposure of the public is almost always in the controlled environment of dental and medical procedures.

Somatic and Genetic Effects

Somatic

Somatic effects are concerned with symptoms produced only in the irradiated person and which result from direct damage to body cells. They are divided into two classes which have been named "early" and "late" effects. In general toxicology, they would be termed "acute" and "chronic".

Early effects occur from large doses of radiation acting over a short time to a large area of the body, producing clinical symptoms within hours, days, or weeks. The conditions occur as the result of a massive depletion of body cells resulting from cell death and a failure to reproduce at a required rate. The level of the effect will, to a large extent, be dictated by damage to the bone marrow, the gastrointestinal tract, and the neuromuscular system.

Radiation sickness, with symptoms of nausea and vomiting, can occur after a few hours. It results from absorption of about 1 Gy and is related to cell damage in the intestines. Higher doses of between 3 and 10 Gy cause depletion of white blood cells and a reduction in the body's defence mechanism against infection. Death usually results within about a month, generally by secondary infection. The dose range 3 to 10 Gy is called the region of infection death.

Doses higher than 10 Gy may be lethal within about five days and generally result from severe damage to the lining of the intestines, followed by massive invasion of the body by bacteria. It is called the region of gastrointestinal death.

With higher doses, death occurs within a few days with symptoms consistent with damage to the central nervous system (CNS). It is described as the region of CNS death.

Other effects which result from high radiation doses are erythema (reddening of skin), loss of weight, loss of hair, changes in skin pigmentation and blistering or ulceration of the skin.

Acute skin effect	Dose (Gy)	Onset
Early transient erythema	2	Hours
Faint erythema; epilation	6-10	7-10 days
Definite erythema; hyperpigmentation	12-20	2-3 weeks
Dry desquamation	20-25	3-4 weeks
Moist desquamation	30-40	4 weeks
Ulceration	>40	6 weeks

Genetic

Genetic effects of radiation result from damage to male or female reproductive cells. When the chromosomes or genes are altered, the hereditary character may be changed so that characteristics will occur in the offspring which were not present in the parents.

Such a reproductive change is called a genetic mutation. Not all mutations produce harmful effects but following irradiation of reproductive organs the possibility of malformation or diseases in offspring is increased. Because of the way in which reproductive cells function, effects resulting from a mutation can occur in subsequent generations of offspring.

Matters to be considered when undertaking an Ionising radiation risk assessment

The ILO code of practice “Ambient factors in the workplace” (section 5) lays down the following matters for consideration when undertaking the risk assessment:

- the nature and magnitude of potential exposures and the likelihood of their occurrence.
- the limits and technical conditions for operation of the source.
- the ways in which structures, systems, components, and procedures related to radiation protection or safety might fail, singly or in combination, or otherwise lead to potential exposures, and the possible consequences of such failures.
- the ways in which changes in the environment could affect protection or safety.
- the ways in which operating procedures related to protection or safety might be erroneous, and the consequences of such errors.
- the protection and safety implications of any proposed modifications.

The risk assessment is required to be documented and kept under review. For example, if there are significant modifications to a radioactive source or to its associated plant, or if there are any changes to national guidelines concerning ionising radiation.

Practical Measures to Reduce or Minimise Exposure

There are several practical measures to reduce or minimise exposure to Ionising Radiation.

These include:

- Engineering controls and design features. These are normally built into the facility or device; they include all aspects of the design and construction which can restrict exposure.
- Safety features are intended to help ensure the safe use of the equipment in normal operation and to prevent unintended exposure in the event of a failure of control devices or systems of work. Examples include locks on exposure controls, door interlocks for enclosures, and devices which will terminate an exposure in the event of an emergency.
- For some work activities, such as industrial radiography, it is appropriate to supply employees with personal dosemeters fitted with an alarm to alert wearers of a high dose rate, for example when a source has failed to retract into a safe position.

External radiation exposure controls

To keep radiation doses low, there are three key control measures that are usually adopted:

Time:

The more time one is exposed to ionising radiation, the larger the dose that will be received and the more harmful the radiation will be. The relationship is linear: doubling the exposure time doubles the dose that is received. This means that if someone is exposed for two hours, the dose would be two times the dose compared to if the exposure were one hour.

Distance:

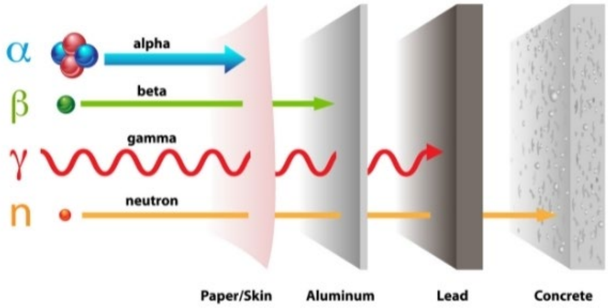
The second very efficient way of minimising the doses is increasing distance. The nature of ionising radiation is such that there is an inverse square law relationship between dose and distance. If we increase the distance from the source from one metre to two metres, the dose will decrease by a factor of four. If the distance is increased from one metre to three metres, the dose will decrease by a factor of nine. So whenever possible, we must be as far as possible from the source. For example, If the distance is increased from 1 m to 2 m, the dose will be reduced by a factor of 4 (1/22). If the distance is increased from 1 m to 3 m, the dose will be reduced by a factor of 9 (1/32). Unfortunately, this is not always possible.

Shielding:

Whenever necessary, doses can be reduced using shields. Different shielding material is used depending on the nature of the ionising radiation. The most common material is lead due to its high density and convenient price.

There are activities that require workers to be close to the source and in a high radiation field. In that case, we minimise the doses by using shielding and protective clothing. When working with X- ray devices in medicine, the most common personal protective clothing is lead aprons. Led aprons made of 0.25 mm thick lead attenuate X-rays

more than 100 times. In some cases when eyes are exposed, spectacles made of lead glass are used as protection. Also, lead gloves can be used, however such gloves are quite thick and not appropriate for detailed work.



When carrying out NDT (non-destructive testing) work on, for example, welds on pipes the source can be "collimated". This is basically a lead shield placed around the source to direct the radiation in one direction (through the weld) and to prevent "scatter."


Image source - https://pl.pinterest.com/damk70damk/_saved/

Internal Radiation Exposure Controls

When working with open or unsealed sources of radioactive material, as well as having a possible external hazard to contend with, workers are faced with the possibility that radioactive material might find its way into the body.

As an internal radiation hazard shielding, distance and time would no longer afford protection.

Only by a combination of physical half-life and biological half-life can the material be eliminated from the body - some may remain there forever.

Small amounts of radioactive material inside the body can be more harmful than much larger amounts outside the body.

Every effort must be made, therefore, to prevent radioactive material from entering the body.

Routes of entry into the body are via the mouth by inhalation or ingestion and through the skin via cuts or absorption. Internal contamination can be avoided by adopting good working practices, and by following some basic precautions, such as:

- Use of materials of minimum radiotoxicity
- Use of the minimum quantities
- Containment, to prevent spread of contamination

- Cleanliness and good housekeeping
- Good hygiene, control of smoking, eating, and drinking
- Use of appropriate protective equipment

9.14: Musculoskeletal issues and manual handling

Basic understanding of the human musculoskeletal system

Introduction

The musculoskeletal system provides form, support, stability, and movement to the body. It is made up of the bones of the skeleton, muscles, cartilage, tendons, ligaments, joints, and other connective tissue that supports and binds tissues and organs together.

The muscular system is composed of specialized cells called muscle fibres. Their predominant function is contractibility. Muscles, attached to bones or internal organs and blood vessels, are responsible for movement. Nearly all movement in the body is the result of muscle contraction.

The combined action of joints, bones, and skeletal muscles produces obvious movements such as walking and running. Skeletal muscles produce more subtle movements that result in various facial expressions, eye movements, and respiration.

In addition to movement, muscle contraction fulfils other important functions in the body, such as posture, joint stability, and heat production. Posture, such as sitting and standing, is maintained because of muscle contraction.

The skeletal muscles are continually making fine adjustments that hold the body in stationary positions. The tendons of many muscles extend over joints and in this way, contribute to joint stability.

Heat production, to maintain body temperature, is an important by-product of muscle metabolism. Nearly 85 percent of the heat produced in the body is the result of muscle contraction.

The Skeleton

The skeletal system is made up of bones and joints and is the basic support structure of the body.

It consists of the joined framework of bones called the skeleton.

The human skeleton is made up of 206 bones.

Additionally, the skeletal portion of the system serves as the main storage depot for calcium and phosphorus.

Bones

Made mostly of collagen, bone is living, growing tissue.

Collagen is a protein that provides a soft framework, and calcium phosphate is a mineral that adds strength and hardens the framework. This combination of collagen and calcium makes bone strong and flexible enough to withstand stress.

Tendons

A tendon is a flexible band of tissue that connects muscles to bones.

Tendons can be small (such as in the hand or ankle) or large, such as the Achilles tendon in the heel.

Tendons help to create movement by making the muscles push or pull the bones in different ways.

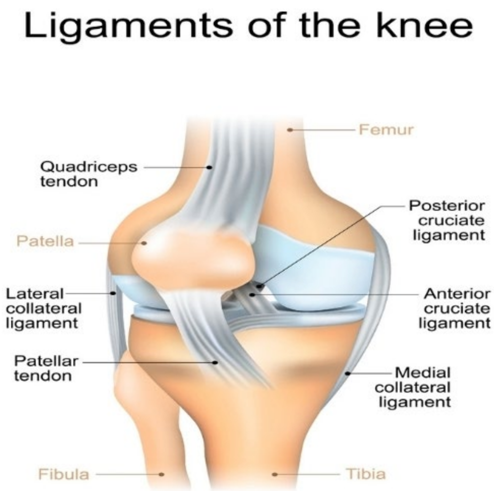
Muscles, Ligaments and Joints

The point at which two or more bones are connected is called a joint.

In all joints, the bones are kept from grinding against each other by a lining called cartilage. Bones are joined to bones by strong, elastic bands of tissue called ligaments.

Muscles are connected to bones by tough cords of tissue called tendons.

Muscles pull on tendons to move joints. Although not technically part of a joint, muscles are important because strong muscles help support and protect joints.



Nerves

The nervous system consists of the brain, spinal cord, sensory organs, and all the nerves that connect these organs with the rest of the body.

Together, these organs are responsible for the control of the body and communication among its parts.

The brain and spinal cord form the control centre known as the central nervous system (CNS), where information is evaluated, and decisions made.

The sensory nerves and sense organs of the peripheral nervous system (PNS) monitor conditions inside and outside of the body and send this information to the CNS.

Efferent nerves in the PNS carry signals from the control centre to the muscles, glands, and organs to regulate their functions.

The Spine

The spine is our body's central support structure. It keeps us upright and connects the different parts of our skeleton to each other, such as the head, chest, pelvis, shoulders, arms, and legs. Although the spine is made up of a chain of bones, it is flexible due to elastic ligaments and spinal disks.

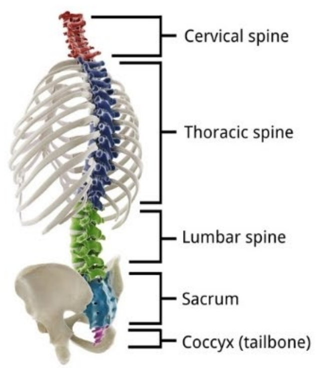
The spine has many functions: It carries the weight of your head, torso, and arms, and allows your body to move in any direction. Some sections of the spine are more flexible than others. The neck is the most flexible part. The spine also surrounds and protects the spinal cord. This important part of the nervous system runs through the middle of the spinal canal.

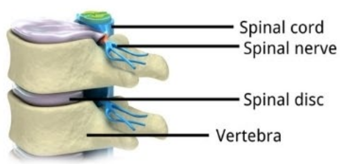
Adults normally have 26 vertebrae, from top to bottom:

- 7 cervical vertebrae
- 12 thoracic vertebrae
- 5 lumbar vertebrae
- 1 sacrum
- 1 tailbone (coccyx)

There are 23 elastic spinal discs between each of the vertebrae - except for between the skull and the first cervical vertebra, and between the first and second cervical vertebrae.

The discs have a solid, multi-layered casing of cartilage fibre and a gel-like core. They keep the spine flexible so that we can lean over and rotate our upper body. They also absorb shocks that are transferred to the spine when we run or jump.





The Types of Injury and Ill-health Conditions Resulting from Repetitive Physical Activities

Manual Handling and Poor Posture

Poorly designed workplaces, repetitive and intensive tasks carried over long periods and poor work environment all contribute to a variety of musculoskeletal related types of ill health. They include:

Back pain/Back injuries:

Back pain ranks high on the list of work-related ailments. Causes include:

- Poor posture
- Overexertion in activities
- Sitting incorrectly at a workstation
- Pushing, pulling, and lifting things incorrectly

Sometimes, the effects are immediate, but in many cases back problems develop over time. One of the more common types of back pain comes from straining the bands of muscles surrounding the spine. Although such strains can occur anywhere along the spine, they happen most often in the curve of the lower back. The next most common place is at the base of the neck. Slipped (prolapsed) disc is another type of back injury that often results in workplace absence.

Work Related Upper Limb Disorders (WRULDs)

Upper Limb Disorders (ULDs) are:

- Aches, pains, tension, and disorders involving any part of the arm from fingers to shoulder, or the neck
- Include problems with the soft tissue's muscles, tendons, and ligaments, along with the circulatory and nerve supply to the limb
- Are often caused or made worse by work

The way the work is organised and managed can make a significant contribution to reducing the risk of ULDs as well as making them worse. They are often referred to as repetitive strain injuries (RSI) or cumulative trauma disorder.

Early symptoms include tenderness; aches and pain; stiffness; weakness; tingling; numbness; cramp; swelling.

Eye and Eyesight Effects

Typically associated with the use of Display Screen Equipment (DSE). However, the HSE reports that extensive research has found no evidence that DSE work can cause disease or permanent damage to eyes. However, long spells of DSE work can lead to tired eyes and discomfort.

This can be controlled by ensuring that the DSE is well positioned and properly adjusted; workplace lighting is suitable and screen glare controlled and regular breaks are undertaken.

Fatigue

Some types of work, for example concentrating for extended periods of time, performing repetitious or monotonous work, and performing work requiring continued physical effort can increase the risk of fatigue.

Exposure to rapid changes in temperature or extreme temperatures can cause fatigue. For example, you might experience fatigue from sitting near a heating or air vent or working in cold or hot environments.

Other environmental causes include insufficient lighting and light glare that result in eyestrain and working around constant or loud noises.

Stress

Pain in the neck and upper extremity is associated with high frequency in repetitive work, but psychological factors have received considerable attention over the past few years. If psychological factors are a factor of in the development of pain in repetitive work, stress symptoms would likely be on the causal path.

A 1994-95 study in the USA involved 2033 unskilled workers with continuous repetitive work and 813 workers with varied work were enrolled. Measures of repetitiveness and force requirements were quantified using video observations to obtain individual exposure estimates. Stress symptoms were recorded at baseline and after again approximately one, two, and three years later.

Repetitive work, task cycle time, and quantified measures of repetitive upper extremity movements including force requirements were not related to occurrence of stress symptoms at baseline or development of stress symptoms during three years of follow up.

The findings do not indicate that repetitive work is associated with stress symptoms, but small effects cannot be ruled out. Thus, the results question the importance of mental stress mechanisms in the causation of pain related to repetitive work.

Sprains/Strains, Fractures and Lacerations

Half a million MSDs were reported to the HSE in the UK in 2019/2020.

The most common injuries are sprains and strains, to the back, legs and arms and bruises, lacerations and fractures to the fingers, hands, toes, and feet.

The types of ill-health conditions resulting from sitting for long periods

Working from a sitting position uses less energy than when standing or moving.

Studies has linked prolonged periods of sitting with several health concerns, including obesity, abnormal levels of cholesterol and increased blood pressure. There is also evidence that prolonged periods of sitting seem to increase the risk of death from cardiovascular disease and cancer.

Extended sitting, such as users of display screen equipment or drivers, can be harmful.

Ways in which risks to workers who must sit for long periods can be reduced, include:

- Taking regular breaks from sitting (a specific requirement of the UK Display Screen Equipment Regulations).
- If working at a desk, try a standing desk — or improvise with a high table.
- Stand whilst talking on a telephone.
- Carry out periodic stretching exercises.

The principles of ergonomic design as applied to the control of musculoskeletal risks

Introduction

Musculoskeletal disorders (MSDs) are injuries or pain in the body's joints, ligaments, muscles, nerves, tendons, and structures that support limbs, neck and back. MSDs are degenerative diseases and inflammatory conditions that cause pain and impair normal activities.

Specific disorders of the musculoskeletal system may relate to different body regions and occupational work. For example, disorders in the lower back are often correlated to lifting and carrying of loads. Upper limb disorders (fingers, hands, wrists, arms, elbows, shoulders, neck) may result from repetitive or long-lasting static force exertion or may be intensified by such activities.

Ergonomics is the science concerned with "the ‘fit’ between people and their work. It puts people first, taking account of their capabilities and limitations. Ergonomics aims to make sure that tasks, equipment, information and the environment fit each worker".

The goal of ergonomics is to reduce stress and eliminate injuries and disorders associated with the overuse of muscles, bad posture, and repeated tasks. This is accomplished by designing tasks, workspaces, controls, displays, tools, lighting, and equipment to fit the employee´s physical capabilities and limitations.

In the early 2000s, NIOSH funded 10 field-based studies to examine the exposure-response relationship between job physical risk factors and work-related musculoskeletal disorders.

The studies focused on either the lower back or the upper extremity. Each of these studies addressed limitations of previous research on work-related musculoskeletal disorders by (1) having a prospective design; (2) making direct and quantitative measurements of job physical risk factors. (3) assessing psychosocial and work organization factors; (4) collecting self-reported symptoms; and (5) assessing musculoskeletal symptoms and disorders through physical examinations.

The results of many of these studies are compiled and published in a special issue of a peer-reviewed journal. These studies collectively showed a strong link between job physical exposures and work-related musculoskeletal disorders.

Ergonomic Design Principles

Applying ergonomics to the workplace can:

- Reduce the potential for accidents.
- Reduce the potential for injury and ill health.
- Improve performance and productivity.

For example, in the design of process control panels consider:

- The location of switches and buttons - switches that could be accidentally knocked on or off might start the wrong sequence of events that could lead to an accident.
- Expectations of signals and controls - most people interpret green to indicate a safe condition. If a green light is used to indicate a ‘warning or dangerous state’ it may be ignored or overlooked.
- Information overload - if a worker is given too much information, they may become confused, make mistakes, or panic. In hazardous industries, incorrect decisions or mistaken actions have had catastrophic results.

Ergonomics can also reduce the potential for ill health at work, such as aches, pains and damage to the wrists, shoulders and back, noise-induced hearing loss and work-related asthma. Consider the layout of controls and equipment - they should be positioned in relation to how they are used. Place those that are used most often where they are easy to reach without the need to stoop, stretch or hunch.

As in risk assessment, an ergonomics approach is important in developing interventions to reduce risk. A participative approach to solution finding is the most effective method for intervention development. Interventions may involve changes to the task, the working environment, or the individual (or work group) or to all of these. Research has shown that interventions that take account of all these aspects are more effective in reducing risk and is often referred to as TILE (Task, Individual, Load, Environment)

Task: changes to the work task(s) may include redesign of the workstation and work equipment. It may include the provision of appropriate furniture, equipment or tools that have been matched to the needs of the workers and the task. Job rotation (in order to reduce risks associated with repetitive tasks) or automation may be beneficial in reducing MSD risks.

Individuals: Training and provision of information to individuals or work groups may also be needed to support other changes.

Load: Consider the weight of the load and the weight of the equipment being used by the worker. Good stability of the hands will help control the load. The load should be stable for negotiating any uneven surfaces. Ensuring the route for any load is wide enough and that any equipment used to wheel the load is well maintained.

Environment: Changes to the environment could include modifications to the thermal conditions, vibration exposure or lighting levels. Changes to influence psychosocial factors may be required. A review of the work organisation and structure such as reduction of work hours or changes to scheduling of breaks or modifying pacing or incentive schemes may also be helpful.

Other factors to consider:

- Repetitive work
- Uncomfortable working postures
- Sustained or excessive force
- Carrying out a task for a long period of time
- Individual differences and susceptibility (some workers are more affected by certain risks)

Case Study 1

Eddie works on an engine assembly line. He uses a handheld impact wrench to fit a component to an engine. The assembly line makes up to 2400 engines a day and it takes approximately 3 seconds to tighten each component.

As well as the risk from using a vibrating tool, Eddie often had to adopt poor postures to reach some parts of the engine. He had to repeatedly stretch out his arm and constrain his posture while tightening the adapter. After a few weeks Eddie found that he was leaving work with shoulder and neck pain. One tea break, Eddie's line manager saw him rubbing his neck and shoulder and recognised that the pain could be due to the type pf work Eddie was doing. The line manager spoke with Eddie and then told the company health and safety officer about what she had seen.

The company assessed the work by considering ergonomics principles and, after getting ideas from the workforce, came up with the following modifications:

- They replaced the impact wrench with one with minimal reaction force so that little shock was transmitted to the hand. They also suspended the wrench so Eddie didn't have to support its weight
- They modified the workplace layout so workers had better access to all sides of the engine, avoiding the need to adopt poor working postures
- They implemented a job rotation scheme so the five workers on the line were moved around a number of different tasks

Some of these tasks still required the use of vibrating tools, but the overall personal exposure was halved. As a result of the modifications there was:

- A reduction in vibration exposure
- No need to adopt poor and constrained postures
- Reduced boredom and fatigue for Eddie's team
- Improved productivity

Case Study 2

Julie is a receptionist at a bank. Much of her work involves using a telephone to take messages and redirect calls to other departments. Julie regularly uses a computer to make appointments, record messages and respond to emails.

After working at reception for eight months, Julie found she was leaving work with an aching shoulder and neck, and with sore eyes and a headache. Julie talked about the problems with her manager, who decided to review how computers were used in reception.

Her manager carried out a DSE assessment, and also looked at the work Julie was doing at reception.

- The DSE assessment identified that Julie's computer screen was difficult to read because of glare and reflections from light through the window. This meant that she would repeatedly adjust her posture to view the screen
- In addition, her manager also identified that Julie would often hold the telephone between her shoulder and ear while talking on the phone and typing a message on the computer. She regularly adopted this awkward posture during her working day.

The assessment led to the introduction of simple, cost effective measures to reduce the risks:

- With the help of her manager, Julie rearranged her workstation so that the screen no longer faced the window, to remove the glare
- An eye test to establish if Julie had any problems with her vision
- A hands-free telephone headset was provided, which helped eliminate Julie's neck and shoulder problems.

As a result, Julie's health problems diminished, and her productivity increased.

When a manual handling risk assessment is required

Where you identify risks from hazardous manual handling in your workplace that cannot be avoided, you should carry out a manual handling risk assessment to help you decide what you need to do to manage these risks.

Your workforce, or their representatives, should be fully involved in the risk assessment process.

The UK HSE (in their publication L23) recommend a series of filters that can be used to decide if a detailed assessment is required.

The Filters

The filters are based partly on data in published scientific literature and partly on practical experience of assessing risks from manual handling. They are pragmatic, tried and tested and set out approximate boundaries that will provide a reasonable level of protection to around 95% of working people.

There are different filters for four types of manual handling operations. These are:

- lifting and lowering
- carrying for up to 10 m
- pushing and pulling for up to 20 m
- handling while seated

Lifting and lower risk filter

Each box in the following figure contains a filter value for lifting and lowering in that zone. The filter values are reduced if handling is done with arms extended, or at high or low levels, as that is where injuries are most likely to happen. (Source of Diagram: HSE)

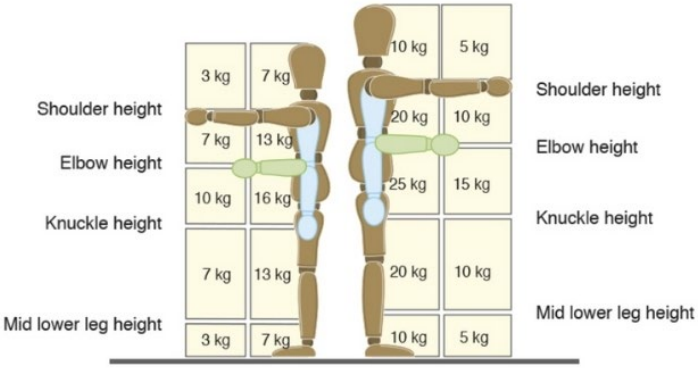


Image source - https://www.hse.gov.uk/msd/manual-handling-risk-filters.htm

Observe the work activity you are assessing and compare it to the diagram.

First decide which zone or zones the lifter's hands pass through when moving the load. Then assess the maximum weight being handled. If it is less than the value given in the matching box, the operation is within the guidelines.

If the lifter's hands enter more than one zone during the operation, use the smallest weight. If either the start or end positions of the hands are close to a boundary between two boxes you should use the average of the weights for the two boxes.

The filter for lifting and lowering assumes:

- the load is easy to grasp with both hands.
- the operation takes place in reasonable working conditions.
- the handler is in a stable body position.

Carrying risk filter

The filter weights for lifting and lowering in Figure opposite apply to carrying operations where the load:

- Is held against the body
- Is carried no further than about 10 m without resting
- Does not prevent the person from walking normally
- Does not obstruct the view of the person carrying it
- Does not require the hands to be held below knuckle height or much above elbow height (owing to static loading on the arm muscles)

Where the load can be carried securely on the shoulder without first having to be lifted (as, for example, when unloading sacks from a lorry) you can apply the filter values to carrying distances up to 20 m.

If the weight lifted exceeds the filter weight or these assumptions are not met, then a more detailed assessment may be required.

Image source - https://www.hse.gov.uk/msd/manual-handling/good-handling-technique.htm

Pushing and pulling risk filter

In pushing and pulling operations the load might be slid, rolled, or moved on wheels. Observe the general posture being used while the pushing or pulling operation is being carried out. The task is

likely to be low risk if:

- The force is applied with the hands
- The torso is largely upright and not twisted
- The hands are between hip and shoulder level
- The distance involved is no more than about 20m

An additional indicator that the task is low risk is if the load can be moved and controlled easily with only one hand.

If the task requires significant forces for pushing and pulling, as indicated by the posture while the operation is being carried out, then a more detailed assessment may be required. Images show acceptable push/pull postures.

Image source - https://www.hse.gov.uk/pubns/indg143.pdf

Handling while seated risk filter

The filter values for handling operations carried out while seated, shown in the image are:

- Men – 5kg
- Women – 3kg

These values only apply when the hands are within the zone shown. If handling beyond this box zone is unavoidable, you should make a full assessment.

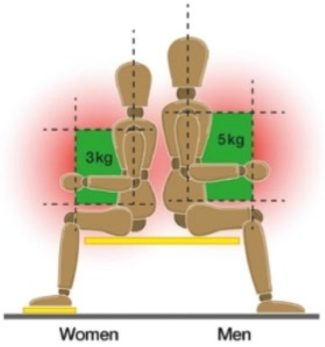


Image source - https://www.hse.gov.uk/pubns/indg143.pdf

How to decide if a more detailed assessment should be used

A more detailed assessment will be required when any of the following conditions apply:

- Lifting or lowering takes place outside the box zones in the lifting and lowering image, such as with very large forward reaches, lifting below floor level or lifting above head height.
- The handling is more frequent than one lift every two minutes.
- The handling involves torso twisting
- Team handling occurs
- The activities are complex
- The load is difficult to grasp or handle
- Aspects of the working conditions are not ideal
- Carrying happens with the load not held against the body

Circumstances when the following assessment tools should be used

HSE Manual Handling Assessment Tool (MAC)

Within the UK The MAC uses a numerical score and a traffic light approach to indicate the level of risk.

It can be used to look at three types of manual handling operation:

- Lifting by one person
- Carrying by one person
- Team handling

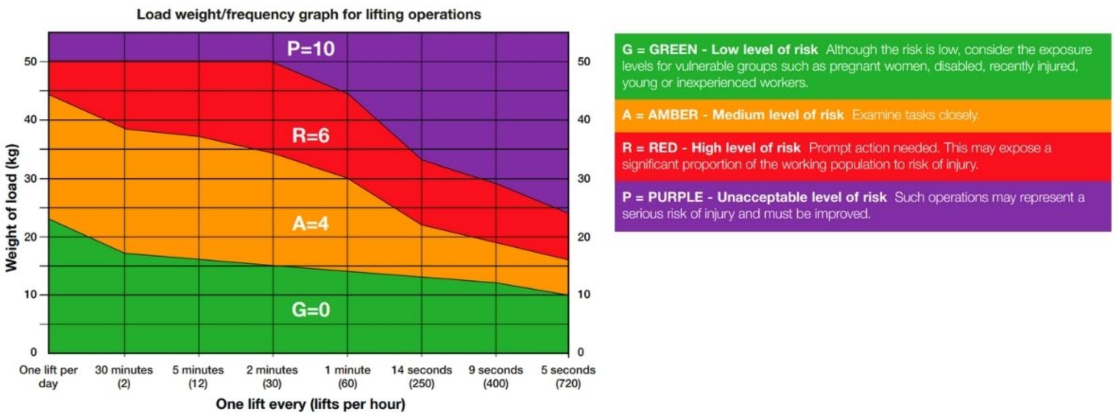


Image source - https://www.hse.gov.uk/pubns/indg383.pdf

HSE Assessment tool for repetitive tasks of the upper limbs (ART).

Within the UK The ART tool is designed to help assess repetitive tasks involving the upper limbs.

It assesses some of the common risk factors in repetitive work that contribute to the development of upper limb disorders.

Repetitive tasks are made up of a sequence of upper limb actions, of fairly short duration, which are repeated over and over again, and are almost always the same (for example, stitching a piece of cloth; packaging one item).

- ART is most suited for tasks that:
  - involve actions of the upper limbs,
  - repeat every few minutes, or even more frequently and,
  - occur for at least 1–2 hours per day or shift.
- The tasks are typically found in assembly, production, processing, packaging, packing, and sorting work, as well as work involving the regular use of hand tools.
- ART is not intended for display screen equipment (DSE) assessments.

HSE Variable Manual Handling Assessment chart (V-MAC)

The V-MAC is a tool for assessing manual handling operations where load weights vary. It should be used in conjunction with the MAC tool.

The MAC tool was designed for assessing handling operations where the same weight is handled over the workday/shift. However, in practice, load weights are often variable (such as in order picking, parcel sorting, trailer loading/unloading, and parts delivery in manufacturing). The V-MAC was developed to help assess these kinds of jobs.

The HSE's DSE Workstation Checklist

For regular users of Display Screen Equipment there is a specific tool known as the HSE's DSE Workstation Checklist.

DSE users spend many hours sat or stood at their computer workstations, carrying out repetitive motions with their hands and holding their backs and necks in static positions.

For organisations who employ large numbers of computer users (such as financial services, call centres, administration, etc.) the risk of WRULDs from DSE operations can be significant.

The DSE Workstation checklist is designed to be used for each individual workstation. It is a simple checklist asking questions and showing images of good and bad practice. Whilst the H&S practitioner can do all the risk assessments themselves, the checklist is so simple that the users often self-risk assess their own workstations.

The checklist also suggests possible corrections for the user to implement, such as specific changes to the layout of their desk. For example, the user is prompted to move their keyboard to the optimum position.

Display screen equipment (DSE) workstation checklist (Click here) http://www.hse.gov.uk/pubns/ck1.pdf

Practical Control Measures to Avoid or Minimise the Risk following the Hierarchy of Control

Elimination

Wherever possible, the task should be eliminated. This is not always easy, but with some creativity it is possible. Often, elimination of the task also increases productivity and reduces cost. Manual handling requires people, which costs money.

To eliminate a task means saving on labour costs. In fact, most elimination of tasks is done for cost reasons. The risk reduction is often just a side-benefit.

Let us discuss an example, to see one way of eliminating a task.

Case Study

A manufacturer of plastic sheets and nets uses plastic resin pellets as its main raw material. This is delivered in 25kg bags, stacked on pallets. The bags are lifted off manually, opened with a knife, and the contents poured into a container. The machinery then sucks up the pellets into a hopper, from where they are dropped into a melting process.

The manual handling task was assessed as high risk. The vertical distance of the lift ranged from reaching upwards to lift a bag from the top of the stack to lifting bags off the lowest level of the pallet (almost at floor level). The task was frequent. The process required several tons of resin every day.

Not only was the task high risk, but it took many hours of labour, The organisation decided to make this task more efficient.

A project team was put together to analyse the task and come up with options to reduce the handling. The recommendation was to purchase the resin pellets in bulk containers. These could have an opening at the top on the container to feed in the vacuum pipe from the hooper. All manual handling would be eliminated.

The organisation had to purchase several cone shape bulk containers to provide to the manufacturer of the resin. These were reusable. They would be delivered full of resin. The empty containers would be returned to the supplier for reuse.

Thanks to the change in purchasing specifications, the organisation saw significant cost savings. Not only was there a large saving in labour hours, the change eliminated more of the disposable packaging costs (pallets, bags, shrink wrapping etc).

Automation

The automation of handling processes is becoming more and more common place as technology improves and labour costs increase.

However, material handling has been automated for many years with the use of powered conveyor belts. These belts carry materials and products from one place to another. They are a common and cost-effective option where there are many products that need to be moved between two locations.

Sorting of products and materials has, traditionally, been done manually. But over the past decades, technology has been able to automate these sorting tasks. Now products and materials can be tagged with bar codes or radio-frequency tags, allowing the equipment to identify what it is and what to do with it.

Order picking is becoming automated now. Automatic guided vehicles are available. These can pick products from shelves and transport them to human packers, or automated packing equipment. Conveyors are now able to recognise the individual products on them and direct each individual product to a separate location.

Alternative Work Methods and Job Design

Instead of eliminating the task, the organisation can eliminate the manual handling aspect of the task. This often means introducing load handling equipment.

Most load handling equipment lifts or carries loads. It can be powered (e.g. electric) or manually powered (such as a chain block and tackle). Some equipment doesn't lift or move the load but provides assistance and makes the manual handling easier. For example, a trolley or roll-cage on wheels provide an effective way of moving large, heavy, loads with much less effort. Roller conveyors are another example. The rollers are not powered, but the operator can slide the object across the rollers with ease, significantly reducing the force required.

Case Study

A manufacturer of steel boilers receives heavy components on pallets. This must be lifted off the pallet and onto an assembly jig. The area, like most manufacturing plants, is space restricted. The workers had to lift components weighing up to 40kg from pallets and fix them into position. The risk assessment identified this as a high-risk task.

The organisation employed a contractor to install an electric hoist with an in-line control device. This enables the workers to control the hoist with one hand, whist using the other hand to guide the component into its position.

Whilst the task has not been eliminated, the manual handling risk has been almost entirely removed. However, lifting equipment has been introduced, which is itself a risk. The H&S practitioner must, therefore, decide which risk is greater; the manual handling or the lifting equipment? In most cases, the introduction of lifting equipment is preferable since the risks from this can be more easily controlled.

Ergonomic Design of Tools, Equipment Workstations, and Workplaces

Tools

The use of tools can be forceful and repetitive. If that is the case, there is a significant risk of developing some sort of repetitive strain injury.

The tool must be suitable for the job. For example, the head of the screwdriver should be the appropriate shape and size for the screw. If not, then the user must apply significant pressure to get the screwdriver to grip. Coupled with the twisting motion of screwing, it can cause much discomfort and pain.

The tool should be of the appropriate size and length for the task. Some tools are too long and will not fit in the space. Others can be too short.

The handle of a tool should be comfortable. Most tool handles have an ergonomic design. They are moulded to fit the shape of the average human hand. Some handles are soft, to cushion blows (such as a hammer handle). Others are rigid, with a rough surface for grip.

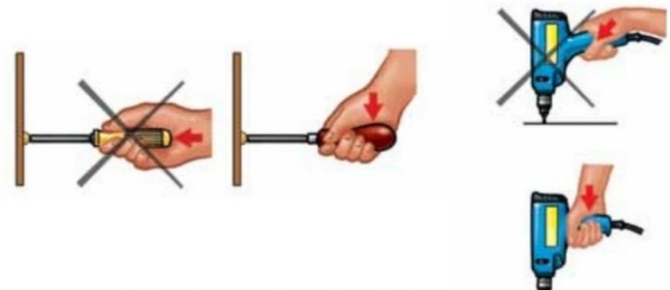


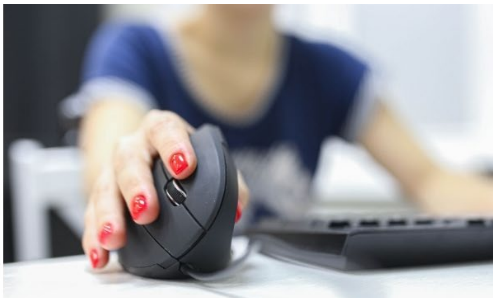
Image source - https://www.hse.gov.uk/pubns/priced/hsg60.pdf

Equipment

Like tools, equipment should be designed with the user in mind and should be suitable for the job it is used for.

If the equipment is hand-held, the hand grips should be comfortable for the user. For example, power drills have moulded handles.

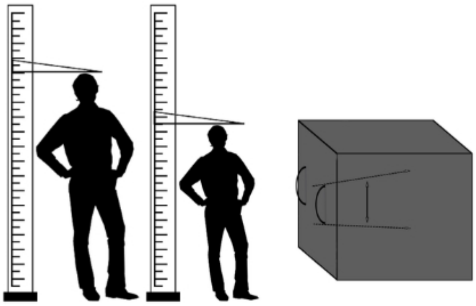
Another example is the "ergonomic computer mouse" which is designed differently to a standard computer mouse to provide a more comfortable wrist position. Power tools and hand-tools should also have handles which enable a comfortable wrist position.



If the equipment has handles, then these should be comfortable. They should also be located so they equipment is easy to hold. The user should not have to bend, crouch, or reach upwards to hold the handles. For example, on a wheelbarrow, the handles are elevated towards the user. On a jackhammer, the handles are positioned at the top, and the equipment reaches approximately the height of the human waist. This avoids any need to crouch.

Image source - https://www.hse.gov.uk/pubns/indg143.pdf

Vertical handles are useful where there is variation in the heights of individuals who use the equipment. They allow for flexible positioning of the hands.



Equipment should be designed to minimise unnecessary, repetitive, and awkward movements. Controls, knobs, levers, and dials should all be positioned so they are easy to reach, without stretching or excessive reaching. If the control is difficult to operate, such as a valve which is tight, then a tool can be provided to assist and give leverage.

Many types of equipment use handles and triggers. The repetitive, forceful, and static use of a trigger can cause a condition known as "trigger finger". It is good practice for handles and triggers to be designed so they can be operated using different fingers. This gives the user the opportunity to use different fingers, allowing the muscles and tendons in the fingers to rest as they alternate.

Wherever possible equipment should be adjustable. Ergonomics is about fitting the equipment to the user. The more it is adjustable, the more likely it can fit a wide range of different size people.

Office chairs for computer workstations, for example, should be fully adjustable in terms of height and angle of the back rest. Better chairs will have an adjustable angle of the seat pan, inflatable lumbar support, adjustable height, and angle of forearm supports, and even a head rest.

Computer monitors will be height adjustable and will be able to tilt and swivel. Keyboards will be able to sit flat or will tilt forwards. Some keyboards can split in the centre and form two separate sections.

Where equipment is heavy and is used in a permanent location, these can be suspended from the ceiling on springs or jibs. These can take the weight of the equipment, reducing the need for the user to carry the weight or grip it forcefully.

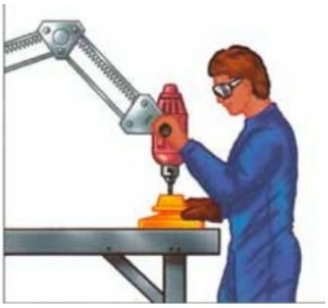


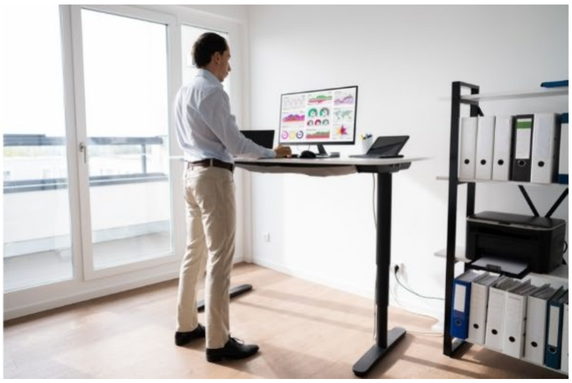
Image source - https://www.hse.gov.uk/pubns/priced/hsg60.pdf

Workstations

Workstations should also be designed with the user in mind and be suitable for how they will be used.

One common method is to set the height of the workstation to the appropriate height. Office desks are usually around 75cm high, which is a good height for an average height man of 1.72m to 1.78m. Of course, many people will be shorter than this. But their chair can be adjusted to raise them to the correct desk height. But if the desk is too low, then anyone over 1.78m will be unable to use it, regardless of any chair adjustments.

Standing desks are also in use in many industries. Again, the height of the desk should be set to accommodate the greatest number of workers.



Workers will find it uncomfortable to stand in one position for a long length of time. The employer should provide footrests to allow the worker to raise their feet and shift position from one leg to another. A good practice is also to provide some form of stool or seating for the worker to lean against or perch on.

Image source - https://www.pinterest.co.uk/ergostandingdesks/home-office-ergonomic-desk-ideas/

Anti-fatigue floor matting can also be provided if workers stand in a static position for considerable periods of time. Whilst this does not solve the problem entirely, it is more comfortable to stand on than a hard floor surface.

Image source - https://commons.wikimedia.org/wiki/File:Anti-fatigue-mats-flooring-bumptop-warehouse.jpg

Adjustable desks are becoming available on the market. These can be manually or electrically adjusted up and down to suit the preferences of a variety of people. They are very useful when different people use the same workstation (known as "hot desking").

Job Rotation and Work Routine

Where a repetitive physical task, manual handling activity, or poor posture cannot be avoided, it is possible to rotate the job between different workers. This minimises the duration and frequency of their exposure to the hazard. It does expose more people to the hazard, but everyone's exposure to the risk should be kept reasonably low.

Job rotation provides an opportunity for the muscles of each person to rest before they are asked to use them again. Sometimes, instead of rotating people around one job, the work routine can be designed to rotate people between different jobs which require a different set of muscles to be used. This allows each muscle group to rest whilst another is used.

Job rotation should not be used where the worker will be using the same set of muscles. This does not allow those muscles to rest.

If used inappropriately, job rotation can increase the risk. It is important that risk to everyone is low as a result of the rotation. If the job rotation simply results in more workers carrying out a high-risk task, there the risk of injury has been increased. Instead of one person possibly being injured, there may be more people injured. This would be counterproductive.

Not all workers may be equally capable of carrying out the task. They may have different strength capabilities, different body shapes, and sizes, and some may have personal health issues. When rotating work between people, it is important to ensure that all people can carry out the task safely.

The work routine should be set up to ensure that workers get adequate rest breaks, and to space the frequency of heavy lifts evenly throughout the days. Situations to avoid are carrying out all the heavy lifting at the end of the shift when muscles are tired. Likewise, at the very start of the shift, the muscles will be cold, and injuries are more likely. After one or two hours of work is when the body is most ready to carry out a heavy lift.

The constant use of Display Screen Equipment puts the user at risk of a temporary strain of the eye muscles. This is not permanent, just temporary. It is caused by the muscles of the eye straining to read the characters on the screen. If we fail to take adequate breaks from the screen, the muscles are held in a static position which strains them. To avoid this, the muscles must constantly move, contract, and relax, like they do in normal use. For permanent users of DSE, the work routine should allow micro-breaks where the user carries out a different task for a brief time.

These are still work activities, but which avoid looking directly at the screen. This can include using a photocopier or printer, fetching some paperwork from another desk or office, using a telephone, having a meeting, or any other activity which avoids the use of the screen.

Where workers are required to stand for long periods of time, the work routine should be designed to give opportunities for movement, sitting down, or rest breaks.

Some jobs require forceful and repetitive movements with hands, such as some conveyor belt works, sorting through small components or squeezing gels from tubes. The work routine should provide for regular stretching breaks where a team-leader ensures everybody pauses and all workers stretch their hands, fingers, tendons, and ligaments, to reduce the risk of strains.

Eye and Eyesight Testing

Further to our previous point about eye strain, the likelihood of this is increased if a person’s eyesight is defective (which occurs naturally over time). If our vision is not perfect, our eye muscles must strain even more to focus on the characters on the display screen.

In the EU and the United Kingdom, it is a legal requirement for an organisation to provide an eyesight test for a DSE user if this is requested. If the optician recommends corrective spectacles for the use of DSE, then the organisation must provide these free of charge.

The provision of corrective spectacles in these cases helps the eye focus on the screen without excessive eye strain.

Training and Information

Workers should be provided with all the necessary training and information for them to recognise the hazards, risks, and what actions to take to protect themselves. They should also know how to recognise the symptoms of ill-health (such as the early signs of repetitive strain injuries) and who to report these to.

Workers should be taught the correct way of using and adjusting their equipment. It should not be assumed that everyone knows how to use common tools and power tools safely. Users should be trained how to use the tools with the minimum force and exertion required for the job. For example, users of screwdrivers should be trained to apply minimum pressure to the screwdriver tip, and instead, use their strength to turn the screw.

They should also be informed about the importance of their grip, how to hold the tool or equipment, and how much force is required to grip it. In the case of vibrating equipment, minimal force is recommended since a forceful grip will transmit more vibration into the hand.

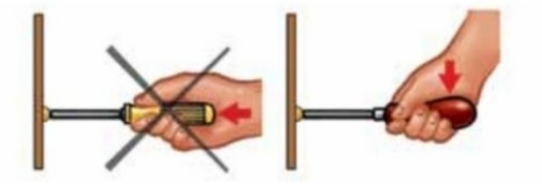


Image source - https://www.hse.gov.uk/pubns/priced/hsg60.pdf

Efficient Movement Principles

A good handling technique is no substitute for other risk-reduction steps, such as providing lifting aids, or improvements to the task, load, or working environment. Moving the load by rocking, pivoting, rolling, or sliding is preferable to lifting it.

However, good handling technique forms a very valuable addition to other risk-control measures. To be successful, good handling technique needs both training and practice. The training should be carried out in conditions that are as realistic as possible, emphasising its relevance to everyday handling operations in the workplace.

There is no single correct way to lift and there are many different approaches, each with merits and advantages based on situations or individual circumstances. The content of training in good manual handling technique should be tailored to the handling operations likely to be carried out, beginning with relatively simple examples, and progressing to more specialised handling operations as appropriate.

For example:

- Workers should be able to identify loads that might cause injury when handled. Increases in size often indicate an increase in weight and difficulty of handling.
- Where the size of the item is less important than how full it is, e.g. in the case of a dustbin containing rubbish, they should assess the load by looking inside it or use techniques such as rocking the load from side to side before attempting to lift it (see Figure).
- They should also treat unfamiliar loads with caution. Drums which appear to be empty or other closed containers should be tested, e.g. by trying to raise one end.
- They should apply force gradually when testing loads. If workers feel too much strain, they should be encouraged to look for another way of handling the load safely.

Figure 17 Rocking a load to assess its ease of handling

Image source - https://www.hse.gov.uk/pubns/priced/l23.pdf

Personal considerations

When considering risks to workers from manual handling or musculoskeletal issues, individual factors need to be considered include:

- medical history
- physical capabilities
- age
- physical condition
- Health conditions
- pregnancy
- lack of work experience, training, or familiarity with the job.

Wearable technologies

Wearable movement sensors and intelligent data analysis is available which can provide information which is not possible through observation alone.

This data and a detailed understanding of how your workforce moves adjustments can be made to enable you to make decisions to improve workplace safety and employee productivity.

Click here - https://www.dorsavi.com/uk/en/visafe/

Case Study

In 2016, dorsaVi partnered with transport industry leaders Jaguar Land Rover and Toyota in the UK as part of their ongoing commitment to improving workplace safety among large manual handling workforces through ViSafe assessments.

As the automotive industry globally employs nine million people producing 60 million cars per year, the auto manufacturers are seeking dorsaVi's help to assess injury risk, validate new techniques to decrease the potential for injury and improve productivity.

Mr Stuart Bassford – Senior Specialist, Toyota Motor Europe said: "At Toyota Motor Europe, we use the standard Toyota philosophy of always looking for a better way as part of continuous improvement. We do this in all business situations including the health and wellbeing of our members."

"This has always been, and always will be, a top priority for us. We are hopeful the trial with dorsaVi will help us continue to develop our evaluation process and enhance our members working experience."

9.15: Temperature in moderate and extreme thermal environments

The importance of maintaining heat balance in the body

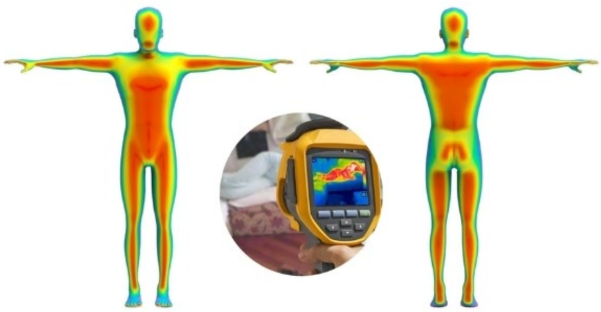
Introduction

Our body temperature must be controlled within a very narrow range so that our body can function properly. A constant core temperature of around 37ºC needs to be maintained. The thermoregulatory centre of the brain triggers changes in effectors, such as sweat glands and muscles, to constantly balance our temperature gains and temperature losses.

Our body can only stay at a constant temperature if the heat we generate is balanced and equal to the heat we lose.

Although our core temperature must be close to 37ºC, our fingers and toes can be colder. This is because energy is transferred from the blood as it travels to our fingers and toes.

The warm thermogram (above) shows the body at normal temperature 37°C (red) - the extremities are cooler (peach and pink areas). The cool thermogram that follows illustrates how the body diverts heat to the core organs to aid survival - the extremities are the coldest areas below 25°C (dark blue).



How our body maintains a constant temperature

Temperature receptors in the skin detect changes in the external temperature. Sensory and relay neurones transmit this information as impulses to the thermoregulatory centre of the brain - the area of the brain responsible for monitoring and controlling temperature.

The thermoregulatory centre also has temperature receptors which detect changes in the temperature of the blood flowing through the brain.

In the event of a change in temperature away from 37oC, the thermoregulatory centre sends electrical impulses to effectors (predominantly in the skin) which bring about responses that correct the temperature back to 37oC.

When the body is too cold: The blood vessels supplying the skin capillaries constrict, causing less blood to flow nearer the surface of the skin, the skin to become pale in appearance, and a reduction of heat loss.

The body shivers - the twitching of muscles generates additional heat as their contraction causes the muscles to respire thus releasing energy to warm the body.

When the body is too hot: The blood vessels supplying the skin capillaries dilate causing more blood to flow nearer the surface of the skin, the skin to become red in appearance, and an increase in heat loss.

The body sweats - which increases heat loss due to the large amount of heat energy required to evaporate the water.

Note that we sweat more in hot conditions, so more water is lost from the body. This water must be replaced through food or drink to maintain the balance of water in the body. Ions such as sodium ions and chloride ions are also lost when we sweat. They must be replaced through food and drink.

The effects of working in high and low temperatures and humidity

Hot Environments

When the air temperature or humidity rises above the range for comfort, problems can arise. The first effects relate to how you feel. Exposure to more heat can cause health problems and may affect performance.

As the temperature or heat burden increases, people may feel:

- Increased irritability.
- Loss of concentration and ability to do mental tasks.
- Loss of ability to do skilled tasks or heavy work.

In moderately hot environments, the body "goes to work" to get rid of excess heat so it can maintain its normal body temperature. The heart rate increases to pump more blood through outer body parts and skin so that excess heat is lost to the environment, and sweating occurs. These changes place additional demands on the body. Changes in blood flow and excessive sweating reduce a person's ability to do physical and mental work. Manual work creates additional metabolic heat and adds to the body heat burden. When the environmental temperature rises above 30°C, it may interfere with the performance of tasks that involve a degree of mental ability.

On a hot humid day, sweat does not evaporate as easily, so the body’s cooling mechanism does not work as well. The limited evaporation in humid conditions is not enough to cool the body.

The reason humidity makes hot weather more unbearable is that the higher the relative humidity, the higher the temperature feels. For instance, a temperature of 88° feels like 88° when the relative humidity is 40%. But increase that humidity up to 75% and that same 88° feels like a whopping 103°!

Exposure to heat extremes can give rise to:

Heat edema is swelling which generally occurs among people who are not acclimatized to working in hot conditions. Swelling is often most noticeable in the ankles. Recovery occurs after a day or two in a cool environment.

Heat rashes are tiny red spots on the skin which cause a prickling sensation during heat exposure. The spots are the result of inflammation caused when the ducts of sweat glands become plugged.

Heat cramps are sharp pains in the muscles that may occur alone or be combined with one of the other heat stress disorders. The cause is salt imbalance resulting from the failure to replace salt lost with sweat. Cramps most often occur when people drink large amounts of water without sufficient salt (electrolyte) replacement.

Heat exhaustion is caused by loss of body water and salt through excessive sweating. Signs and symptoms of heat exhaustion include heavy sweating, weakness, dizziness, visual disturbances, intense thirst, nausea, headache, vomiting, diarrhoea, muscle cramps, breathlessness, palpitations, tingling and numbness of the hands and feet. Recovery occurs after resting in a cool area and consuming cool drinks (e.g., water, clear juice, or a sports drink).

Heat syncope is heat-induced dizziness and fainting induced by temporarily insufficient flow of blood to the brain while a person is standing. It occurs mostly among unacclimatized people. It is caused by the loss of body fluids through sweating, and by lowered blood pressure due to pooling of blood in the legs. Recovery is rapid after rest in a cool area.

Heat stroke is the most serious type of heat illness. Signs of heat stroke include body temperature often greater than 41°C, and complete or partial loss of consciousness. Sweating is not a good sign of heat stress as there are two types of heat stroke - "classical" where there is little or no sweating (usually occurs in children, persons who are chronically ill, and the elderly), and "exertional" where body temperature rises because of strenuous exercise or work and sweating is usually present.

Heat stroke requires immediate first aid and medical attention. Delayed treatment may result in death.

Cold environments

A cold environment challenges the worker in three ways: by air temperature, air movement (wind speed), and humidity (wetness). To work safely, these challenges must be counterbalanced by proper insulation (layered protective clothing), by physical activity and by controlled exposure to cold (work/rest schedule).

Effects of wind chill

At any temperature, you feel colder as the wind speed increases. The combined effect of cold air and wind speed is expressed as "equivalent chill temperature" (ECT) or simply "wind chill" temperature in degrees Celsius or Fahrenheit. It is essentially the air temperature that would feel the same on exposed human flesh as the given combination of air temperature and wind speed. It can be used as a general guideline for deciding clothing requirements and the possible health effects of cold.

In some parts of the World (Canada, for example) the term "wind chill factor" is used. This is a measurement of a heat loss rate caused by exposure to wind and it is expressed as the rate of energy loss per unit area of exposed skin per second (e.g., joules/[second-metre^2] or watts/metre^2, W/m^2).

The figure that follows is adapted from Threshold Limit Values (TLV) and Biological Exposure Indices (BEI) booklet: published by ACGIH, Cincinnati, Ohio, 2016, page 207.

Temperature (°F)

Wind (mph)	Calm 40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Image source - https://en.wikipedia.org/wiki/Wind_chill

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

The table that follows describes the health concerns and potential for frostbite when being outside at various temperatures.

Wind Chill	Exposure Risk	Health Concerns	What to do
0 to -9	Low Risk	• Slight increase in discomfort	• Dress warmly • Stay dry
-10 to -27	Moderate Risk	• Uncomfortable • Risk of hypothermia and frost bite if outside for long periods without adequate protection	• Dress in layers of warm clothing, with an outer layer that is wind resistant • Wear a hat, mittens or insulated gloves, a scarf and insulated waterproof footwear • Stay dry and keep active
-28 to -39	High Risk - exposed skin can freeze in 10-30 minutes	• High risk frostbite - check face and extremities for numbness or whiteness • High risk of hypothermia if outside for long periods without adequate clothing or shelter from the wind or cold	• Dress in layers of warm clothing, with an outer layer that is wind resistant • Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated waterproof footwear • Stay dry and keep active
-40 to -47	Very High Risk - exposed skin can freeze in 5-10 minutes (in sustained winds over 50km/h, frostbite can occur faster than indicated	• Very high risk frostbite - check face and extremities for numbness or whiteness • Very high risk of hypothermia if outside for long periods without adequate clothing or shelter from the wind or cold	• Dress in layers of warm clothing, with an outer layer that is wind resistant • Cover all exposed skin • Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated waterproof footwear • Stay dry and keep active
-48 to -54	Severe Risk - Exposed skin can freeze in 2-5 minutes (in sustained winds over 50km/h, frostbite can occur faster than indicated	• Severe risk of frostbite - check face and extremities for numbness or whiteness • Severe risk of hypothermia if outside for long periods without adequate clothing or shelter from the wind or cold	• Be careful Dress very warmly in layers of clothjing clothing, with an outer layer that is wind resistant • Cover all exposed skin • Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated waterproof footwear • Be ready to cut short or cancel outdoor activities • Stay dry and keep active

Effects of Humidity

Thermal conductivity increases as relative humidity increases, so body heat is more quickly lost in more humid conditions, making it feel colder. All other conditions being equal, a cold day with rain and/or fog feels colder than a dry day.

Thermal comfort

The term 'thermal comfort' describes a person's state of mind in terms of whether they feel too hot or too cold. Environmental factors (such as humidity and sources of heat in the workplace) combine with personal factors (i.e. your clothing) and work-related factors (how physically demanding your work is) to influence your 'thermal comfort'.

Thermal comfort is very difficult to define as you need to consider a range of environmental, work-related, and personal factors when deciding what makes a comfortable workplace temperature.

The best that you can realistically hope to achieve is a thermal environment that satisfies most people in the workplace. Thermal comfort is not measured by room temperature, but by the number of employees complaining of thermal discomfort.

By managing thermal comfort employers are likely to improve morale and productivity as well as improving health and safety. People working in uncomfortably hot and cold environments are more likely to behave unsafely because their ability to make decisions and/or perform manual tasks deteriorates. For example:

- People may take short cuts to get out of cold environments.
- Employees might not wear personal protective equipment properly in hot environments increasing the risks.
- An employee's ability to concentrate on a given task may start to drop off, which increases the risk of errors occurring.

The most used indicator of thermal comfort is air temperature - it is easy to use and most people can relate to it. However, air temperature alone is not a valid or accurate indicator of thermal comfort or thermal stress. It should always be considered in relation to other environmental and personal factors.

The six factors affecting thermal comfort are both environmental and personal. These factors may be independent of each other, but together contribute to an employee's thermal comfort. They are:

- Air temperature
- Radiant temperature
- Air velocity
- Humidity
- Clothing Insulation
- Metabolic heat

Environmental factors

Air temperature:

This is the temperature of the air surrounding the body. It is usually given in degrees Celsius (°C).

Radiant temperature:

Thermal radiation is the heat that radiates from a warm object. Radiant heat may be present if there are heat sources in an environment. Radiant temperature has a greater influence than air temperature on how we lose or gain heat to the environment.

Examples of radiant heat sources include: the sun; fire; electric fires; ovens; kiln walls; cookers; dryers; hot surfaces and machinery, molten metals.

Air velocity:

This describes the speed of air moving across the employee and may help cool them if the air is cooler than the environment.

- Still or stagnant air in indoor environments that are artificially heated may cause people to feel stuffy. It may also lead to a build-up in odour.
- Moving air in warm or humid conditions can increase heat loss through convection without any change in air temperature.
- Physical activity also increases air movement, so air velocity may be corrected to account for a person's level of physical activity.
- Small air movements in cool or cold environments may be perceived as a draught as people are particularly sensitive to these movements.

Humidity:

If water is heated and it evaporates to the surrounding environment, the resulting amount of water in the air will provide humidity.

Relative humidity is the ratio between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold at that air temperature.

Relative humidity between 40% and 70% does not have a major impact on thermal comfort. In workplaces which are not air conditioned, or where the weather conditions outdoors may influence the indoor thermal environment, relative humidity may be higher than 70%. Humidity in indoor environments can vary greatly and may be dependent on whether there are drying processes (paper mills, laundry, etc.) where steam is given off.

High humidity environments have a lot of vapour in the air, which prevents the evaporation of sweat from the skin. In hot environments, humidity is important because less sweat evaporates when humidity is high (80%+). The evaporation of sweat is the main method of heat reduction.

When non-breathable vapour-impermeable personal protective equipment (PPE) is worn, the humidity inside the garment increases as the wearer sweats because the sweat cannot evaporate. If an employee is wearing this type of PPE (e.g. asbestos or chemical protection suits, etc.) the humidity within the PPE will be high.

Personal factors

Clothing insulation:

Thermal comfort is very much dependent on the insulating effect of clothing on the wearer.

Wearing too much clothing or PPE may be a primary cause of heat stress even if the environment is not considered warm or hot.

If clothing does not provide enough insulation, the wearer may be at risk from cold injuries such as frostbite or hypothermia in cold conditions.

Clothing is both a potential cause of thermal discomfort as well as a control for it as we adapt to the climate in which we work. You may add layers of clothing if you feel cold or remove layers of clothing if you feel warm. Many companies inhibit this ability for employees to make reasonable adaptations to their clothing as they require them to wear a specific uniform or PPE.

It is important to identify how the clothing contributes to thermal comfort or discomfort. By periodically evaluating the level of protection provided by existing PPE and evaluating newer types of PPE you may be able to improve the level of thermal comfort.

Work rate/metabolic heat:

The more physical work we do, the more heat we produce. The more heat we produce, the more heat needs to be lost so we do not overheat. The impact of metabolic rate on thermal comfort is critical.

A person's physical characteristics should always be borne in mind when considering their thermal comfort, as factors such as their size and weight, age, fitness level and gender can all have an impact on how they feel, even if other factors such as air temperature, humidity and air velocity are all constant.

Sedentary workers:

Most people will be thermally comfortable in the following conditions:

Condition	Summer	Value	Winter
Air temperature	19-24°C		18-22°C
Relative humidity		40-70%	
Air speed	0.1-0.2 m/s, without creating a draught		
Radiant heat	No direct exposure to a radiant heat source		
Clothing	Light clothing		Winter clothing

If any of these conditions are not met, others will need to be adjusted to maintain comfort. For example, if there is no measurable air movement, the air temperature would need to be lower than the maximum stated.

Active workers:

Because of the addition of physical activity, it becomes less possible to predict a comfort environment. A decrease in the recommended temperatures for sedentary occupations of between 3 to 5°C, or an increase in air speed up to 0.5 m/s, will create a more comfortable environment for people with active work.

Condition	Summer	Value	Winter
Air temperature	16-21°C		16-19°C
Relative humidity		40-70%	
Air speed		0.2 m/s	

Thermal comfort in buildings

Many industrial and commercial buildings are not designed to provide thermally comfortable conditions for employees. Often such buildings allow a high radiant heat loading on the occupants, for example through lack of insulation in roof spaces, or large glass areas in the walls.

For an employer to ensure thermal comfort for employees, some alterations may need to be made to the building itself. An air conditioning system that must compete with a high radiant heat source will never be completely effective.

Typical work situations likely to lead to thermal discomfort

Thermal discomfort is the uncomfortable place between a thermal environment that is ideal, and one that will cause a person to be harmed.

A person feeling thermal discomfort will feel either too hot or too cold. However, a person will not suffer harm as a direct result of the thermal environment.

While a thermal environment that causes discomfort may not directly cause harm, it does have many disadvantages. People can feel tired and irritable. They may be less productive and make more mistakes with their work. There is a greater risk of someone making a mistake that could result in an accident.

The purpose of the heat stress index (WBGT)

Introduction

Heat stress occurs when the body's means of controlling its internal temperature starts to fail. As well as air temperature, factors such as work rate, humidity and clothing worn while working may lead to heat stress. Therefore, it may not be obvious to someone passing through the workplace that there is a risk of heat stress.

A phrase that is often used in the hot summer months is "it's not the heat, it's the humidity". It is actually both. The heat index is what the temperature feels like to the human body when relative humidity is combined with the air temperature.

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Caution | Extreme Caution | Danger | Extreme Danger

A heat index chart factors relative humidity into temperature to provide a more accurate assessment of what the temperature feels like.

The heat index values in the chart above are for shady locations. Exposure to direct sunlight can increase the heat index value by up to 15°F. The table that follows shows that heat indices meeting or exceeding 103°F can lead to dangerous heat disorders with prolonged exposure and/or physical activity in the heat.

Classification	Heat index	Effect on body
Caution	80-90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90-103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103-124°F	Heat cramps, or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

The WBGT measurement can then be compared to an index of Threshold Limit Values which indicates a level of risk and suggested actions. There are several TLVs which apply depending on the country and relevant legislation.

In the United States, OSHA suggest the following limits:

OSHA TABLE III: 4-2. PERMISSIBLE HEAT EXPOSURE THRESHOLD LIMIT VALUE

	Work Load*		
Work/rest regime	**Light**	**Moderate**	**Heavy**
Continuous work	30.0°C (80°F)	26.7°C (80°F)	25.0°C (77°F)
75% work, 25% rest, each hour	30.6°C (87°F)	28.0°C (82°F)	25.9°C (78°F)
50% work, 50% rest, each hour	31.4°C (89°F)	29.4°C (85°F)	27.9°C (82°F)
25% work, 75% rest, each hour	32.2°C (90°F)	31.1°C (88°F)	30.0°C (86°F)

*Values are in °C and °F, WBGT

Table source - https://www.azevap.com/workAreaTempProductivity.php

These assume that all workers are acclimatised to the heat, are fully clothed with light clothing (which does not impede sweat evaporation), with adequate water and salt intake.

The practical control measures to minimise the risks when working in extreme thermal environments

Remove or reduce the sources of heat where possible

Control the temperature

Control the temperature using engineering solutions e.g.:

- Change the processes.
- Use fans or air conditioning.
- Use physical barriers that reduce exposure to radiant heat

Provide mechanical aids.

- Provide mechanical aids where possible to reduce the work rate. Regulate the length of exposure to hot environments by:
- Allowing employees to enter only when the temperature is below a set level or at cooler times of the day.
- Issuing permits to work that specify how long your employees should work in situations where there is a risk.
- Providing periodic rest breaks and rest facilities in cooler conditions.

Prevent dehydration

Working in a hot environment causes sweating which helps keep people cool but means losing vital water that must be replaced. Provide cool water in the workplace and encourage workers to drink it frequently in small amounts before, during (this is not possible in some situations eg respiratory protective equipment use or asbestos removal) and after working.

Provide personal protective equipment

Specialised personal protective clothing is available which incorporates, for example, personal cooling systems or breathable fabrics.

This may help protect workers in certain hot environments. Protective clothing or respiratory protective equipment is often provided to protect from a hazard at work e.g. asbestos. This type of equipment, while protecting the employee from this hazard may expose the employee to heat stress.

Training

Provide training for your workers, especially new and young employees telling them about the risks of heat stress associated with their work, what symptoms to look out for, safe working practices and emergency procedures.

Acclimatisation

Allow workers to acclimatise to their environment and identify which workers are acclimatised/assessed as fit to work in hot conditions.

Identify who is at risk

Identify employees who are more susceptible to heat stress either because of an illness/condition or medication that may encourage the early onset of heat stress, e.g. those with heart conditions.

Advice may be needed from an occupational health professional or medical practitioner. Your risk assessment should already address risks to pregnant employees, but you may choose to review it when an employee tells you she is pregnant, to help you decide if you need to do any more to control the risks.

Monitor health

Monitor the health of workers at risk. Where it is considered that a residual risk remains after implementing as many control measures as practicable, you may need to monitor the health of workers exposed to the risk. You should then seek advice from occupational health professionals with a good working knowledge of the risks associated with working in heat stress situations and consider this as part of your Health Surveillance.

The table that follows provides a summary of some of these controls.

Method of Control	Actions
Engineering Controls	
Reduce body heat production	Mechanise tasks
Stop exposure to radiated heat from hot objects	Insulate hot surfaces. Use reflective shields, aprons, remote controls
Reduce convective heat gain	Lower air temperature. Increase air speed if air temperature below 35°C. Increase ventilation. Provide cool observation booths
Increase sweat evaporation	Reduce humidity. Use a fan to increase air speed (movement)
Clothing	
	Wear loose clothing that permits sweat evaporation but stops radiant heat. Use cooled protective clothing for extreme conditions
Administrative Controls	
Acclimatisation	Allow sufficient acclimatisation period before full workload
Duration of work	Shorten exposure time and use frequent rest breaks
Rest area	Provide cool air (air conditioned) rest-areas
Water	Provide cool drinking water
Pace of work	If practical, allow works to set their own pace of work
First aid and medical care	Define emergency procedures. Assign one person trained in first aid to each work shift. Train workers in recognition of symptoms of heat exposure

Welfare

Why it's important to provide welfare facilities

In most countries it is a legal requirement to provide basic welfare facilities in the workplace. For example:

- EU Directive 89/654/EEC imposes requirements on EU member states concerning the minimum safety and health requirements for the workplace, including the requirements for the provision of adequate welfare facilities.
- ILO Recommendation "C167 - Safety and Health in Construction Convention, 1988 (No. 167)" imposes similar requirements on (temporary) construction sites.
- ILO Recommendation "R102 Welfare facilities recommendation (1956)" specifies basic welfare provisions.

Workers who are provided with good basic welfare facilities (such as clean restrooms, toilets, washing facilities, plentiful water supply) are likely to feel happier in their work and hence, more likely to be more productive. This is the case in both fixed facilities and temporary facilities (such as construction sites).

Lighting

Inadequate lighting is associated with ill-health effects ranging from eye strain, headaches, and fatigue, to postural problems and musculoskeletal disorders (MSDs). In higher-risk environments, such as transport yards, warehouses, and factories, the consequences of a dark or dimly lit workplace can be even more serious, leading to injuries and even fatalities. Put simply: the easier it is to see a hazard, the easier it is to avoid it.

It's not just about poor design or lighting failures. As more people work longer hours in artificial lighting, there is growing evidence that simply too little natural light may have negative effects on the body's natural rhythms, reducing alertness and contributing to depressive conditions such as seasonal affective disorder (SAD).

Facilities for pregnant women and nursing mothers, together with the practical arrangements.

Employers are required to provide suitable rest facilities for pregnant women or who are breastfeeding. The facilities should be suitably located (e.g. near to toilets) and where necessary should provide appropriate facilities for the new or expectant mother to lie down.

Hygiene facilities: Without easy access to toilets (and associated hygiene facilities) at work, due to distance, work processes or systems, etc, there may be an increased risk to health and safety, including significant risks of infection and kidney disease.

Because of pressure on the bladder and other changes associated with pregnancy, pregnant women often have to go to the toilet more frequently and more urgently than others. Breastfeeding women may also need to do so because of increased fluid intake to promote breast milk production.

Storage facilities: Access to appropriate facilities for breastfeeding mothers to express and safely store breast milk.

Seating

A chair which is suitably adjustable is an important part of achieving correct posture when working at a desk and in particular at a computer workstation.

A DSE (Display Screen Equipment) assessment, which included posture should be undertaken.